Trophic Study of Gull Lake

(50° 25′, 96° 31′)

Water Standards and Studies Report #86-7

Manitoba
Environment and
Workplace Safety
and Health

TROPHIC STUDY OF GULL LAKE
(50° 25', 96° 31')

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SUMMARY

Recreationers at Gull Lake in south-eastern Manitoba (50° 25', 96° 31') have long been concerned with water quality problems. Historical concerns were primarily focused upon occasional fish die-offs, whereas more recent concerns have focused upon the excessive proliferation of aquatic macrophytes and possible bacterial contamination of swimming areas. The present report primarily addresses the issue of the macrophyte problem.

Prior extensive commitments precluded a detailed field investigation of the Gull Lake situation by Water Standards and Studies staff. Accordingly, the Gull Lake Ratepayers Association executive proposed to collect the required field samples according to Water Standards and Studies guidelines and also to provide pertinent information as required. This proposal was accepted by Water Standards and Studies and the study undertaken. Because of the nature of the water quality problem (i.e. excessive proliferation of macrophytes) and because of the extensive cottage development around the lake, it was suspected that the issue of aquatic macrophyte proliferation was related to an accelerated rate of eutrophication which had been induced by an excessive nutrient supply. The field study was designed to focus investigation upon this possibility. The Association executive commenced sampling on June 6, 1985 and continued at twice weekly intervals throughout the summer season. Final fall and winter samples were collected by Water Standards and Studies.

Upon completion of sample analysis, the first task was to confirm the fundamental precepts of the study. The first step to achieving this task involved examination of the available nutrient supply. Application of theoretical, potential and calculated-observed nitrogen: phosphorus ratios confirmed that phosphorus was the limiting nutrient for growth. This meant that its proportional availability controlled the rate of macrophyte growth. The second step was to assess the trophic status of Gull Lake. Application of Carlson's TSI indices and Vollenweider's scale revealed that Gull Lake was borderline between mesotrophic and eutrophic. This meant that the current problems with excessive macrophytic growth were a forerunner to much more serious problems with blue-green (cyanophyte) algae blooms. The third step, the development of a phosphorus budget, linked the first two steps and confirmed the fundamental study precepts. The phosphorus budget indicated that approximately 64.9% of the total phosphorus loading to Gull Lake was contributed by artificial sources. Primary among these sources were cottages, which accounted for 54.8% of the total supply. Lesser proportions were contributed by permanent residences (7.8%) and a local campground (2.3%).

It was determined that a substantial reduction in the amount of phosphorus supplied to Gull Lake may reverse the trend of accelerated eutrophication. Assuming that all artificial loadings were eliminated by the installation of holding tanks for wastewaters

and sewage, Gull Lake could revert to a trophic status bordering between oligotrophy and mesotrophy. This would be similar to conditions extant prior to extensive recreational development around the lake. Due to sediment storage of nutrients and translocation by the roots of aquatic macrophytes, the process of trophic state reversion was estimated to be a relatively long period of approximately fourteen years.

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1.0 INTRODUCTION

Gull Lake (50° 25', 96° 31') has a history of public concern with symptoms related to eutrophication dating at least to the 1930's (Department of Natural Resources, Fisheries Branch files). Initially the concerns focused on fish die-offs which had been induced by midwinter oxygen depletions (Ibid). By the late 1960's, the emphasis of public inquiries and complaints had shifted to excessive growth of aquatic macrophytes and the concurrent appearance of swimmer's itch (J. Warrener, pers. comm *). Most recently, questions regarding possible bacterial contamination have arisen (Water Standards and Studies files). However, the primary interest at present continues to focus on excessive growth of aquatic macrophytes (Ibid).

Official responses to public concerns about Gull Lake have also evolved over the course of time. Initial responses involved simple documentation of events such as fish die-offs and public notification regarding symptomatic causes. As the science developed, the root cause of the symptoms, i.e. the onset of eutrophication**, became recognized officially and a number of investigative studies were proposed. However, due to the immaturity of the science, the proposals were cumbersome and fairly labour and cost intensive. Hence the proposals were not enacted. Very recent scientific developments in mathematical modelling of eutrophication have permitted a much more

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* Mr. J. Warrener, Technical Advisor, Clean Environment Commission.

** The term "entrophication" refers to the ageing process of a lake.

cost effective approach to investigative studies. It is this latter approach that was applied during the present study.

The present study was initiated as the result of a May 16, 1985 telephone call by Mr. Don Minty (Executive member, Gull Lake Ratepayers Association) to Mr. Dennis Brown (Head, Water Standards and Studies). The broad concerns of the Association and the possibility of an investigative study were discussed. Study proposals were developed in house, refined and subsequently presented to Association executive members Mr. Don Minty and Mr. Karl Klassen during a May 30, 1985 meeting with the author. It was agreed that the study would be a pilot project wherein field sampling would be conducted by the Association and analysis and interpretation would be performed by Water Standards and Studies.

The primary purpose of the study was to determine the cause of excessive macrophyte growth in Gull Lake. The secondary purpose was to examine a possible ameliorative scenario with a view to assessment of the long term implications. The question of bacterial contamination of swimming areas is the subject of a separate investigation (D. Williamson (in prep.), pers. comm.) and has not been treated in the present study.

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* D. Williamson, Environment Officer, Water Standards and Studies Section.

2.0 METHODS

2.1 Rationale

The literature (Vollenweider, 1968; Vallentyne, 1974) leaves little doubt that the symptoms of frequent fish die-offs, oxygen depletions and excessive macrophyte growth manifested in Gull Lake were due to a nutrient induced accelerated rate of eutrophication. Classic whole lake experiments have implicated phosphorus overabundance as the trigger for accelerated eutrophication (Schindler et al, 1971; Schindler, 1977). Hence the present study focused on development of a phosphorus budget for Gull Lake.

A rigorous water sampling regime was implemented on Gull Lake in order to confirm the validity of the "excessive phosphorus" assumption. A phosphorus budget for the lake was developed using the Hough, Stansbury and Michalski Limited (1980) modelling process. The budget estimated the significance of different phosphorus sources in order to identify those which were amenable to control. Several possible control scenarios were postulated and resultant phosphorus concentrations predicted. Long term implications of the various scenarios were assessed from the literature.

2.2 Field Procedures

The primary objective of the field sampling program was to provide an estimation of the mean total phosphorus concentration [P] at an accuracy level indicated by a mean standard error of less than 10% of the mean. Hence, the water sampling regime was based on a

strategy of stratified random sampling (Cassie, 1971). Based upon previous investigations (Water Standards and Studies, unpublished data), the number of sampling stations was set at six, summer sampling frequency was set at twice weekly and fall and winter sampling frequency was set at once per season. Sampling stations (Figure 1) were located by superimposing a numbered grid upon a map of the lake and utilizing random number tables to determine grid reference points. Sampling depths were determined by considering random numbers a percentage of total depth at each station.

Samples at depth were collected using a 2.2 L pesticide grade acrylic Kemmerer sampler. Depth integrated chlorophyll "a" samples were collected at a maximum of twice the secchi depth by using a Water Standards and Studies sampler. Following instructions in proper sampling technique, all summer sampling (142 samples) was conducted by Mr. Don Minty and Mr. Karl Klassen, both members of the executive of the Gull Lake Ratepayers Association. Fall and winter sampling (12 samples) was conducted by Water Standards and Studies Section.

All samples were delivered to the W. M. Ward Technical Services Laboratory by the collector within twenty-four hours of collection. Analyses were performed at the laboratory according to procedures described by Sorba et al (1980).

2.3 Modelling Procedures

The phosphorus budget for Gull Lake was developed with the aid of a variety of models and data sources. The calculation process has been itemized (Table 1) and discussed in a step by step fashion after the manner of Hough, Stansbury and Michalski Limited (1980).

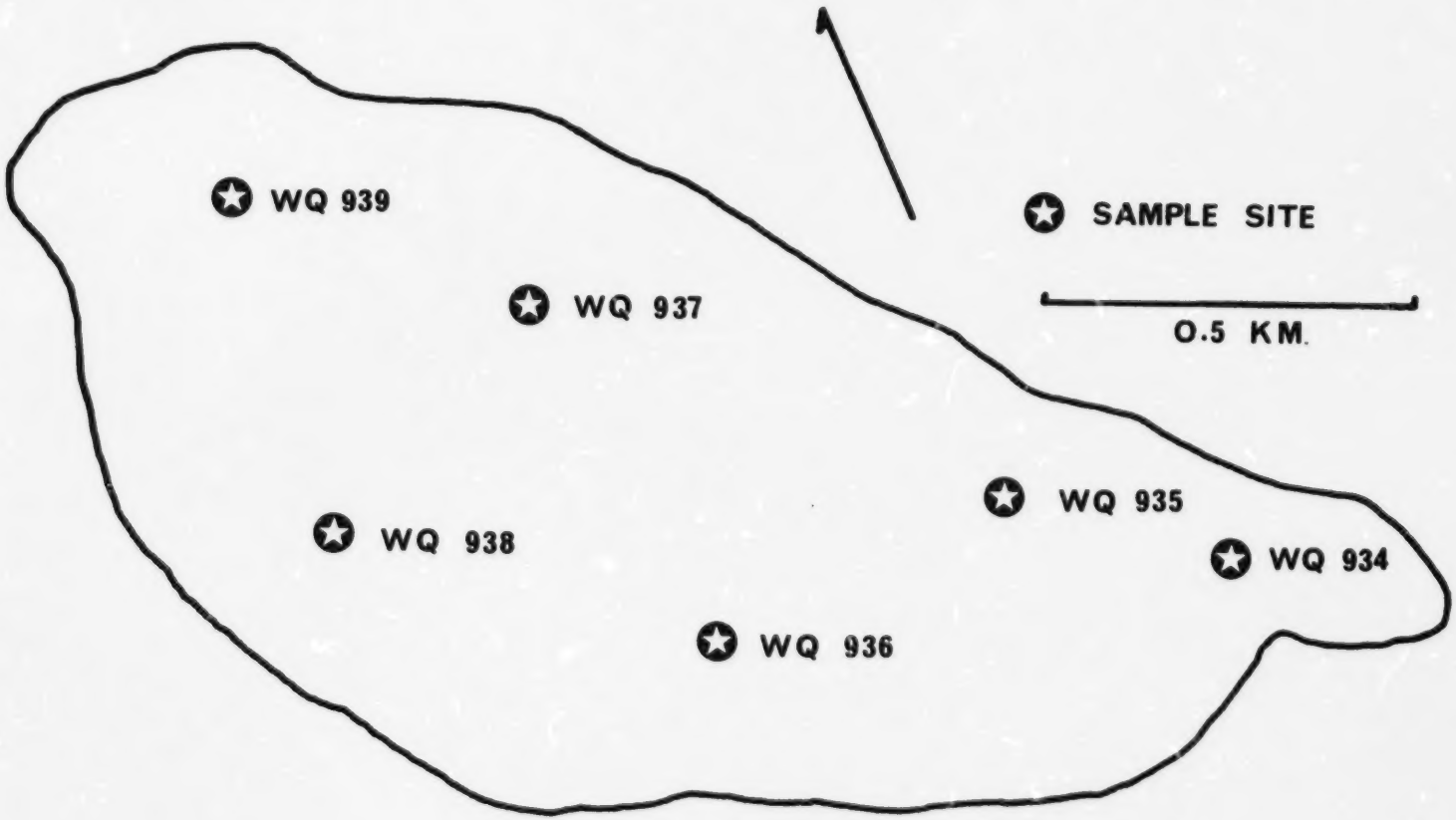

FIGURE I: Gull Lake sampling stations

TABLE 1: CALCULATION PROCESS FOR THE GULL LAKE PHOSPHORUS BUDGET.

STEP	PARAMETER	QUANTITATION
1	Surface Area (Ao)	$1.176 \times 10^6 m^2$
2	Volume (V)	$3.901 \times 10^6 m^3$
3	Mean Depth ($\bar{Z}$ = V/Ao)	3.32 m
4	Drainage Basin (Ad)	$2.953 \times 10^6 m^2$
5	Annual Precipitation (Pr)	0.500 m/yr
6	Net Annual Runoff (r)	0.115 m/yr
7	Net Annual Evaporation (E_V)	0.115 m/yr
8	Outflow ($Q = [Ad \cdot r] + Ao[Pr - E_V]$)	$7.924 \times 10^5 m^3/yr$
9	Flushing Rate (p = Q/V)	0.203 times/yr
10	Areal Water Load (qs = Q/Ao)	0.674 m/yr
11	Retention Coefficient (R = 13.2/13.2 +qs)	0.951
12	P Loading from Precipitation (L_{Pr})	$41 mg/m^2/yr$
13	P Contribution from Precipitation ($J_{Pr} = L_{Pr} \cdot Ao$)	$4.822 \times 10^7 mg/yr$
14	P Export Coefficient (E)	$15 mg/m^2/yr$
15	P Contribution from Drainage Basin ($J_D = Ad \cdot E$)	$4.430 \times 10^7 mg/yr$
16	Total P from Natural Sources ($J_N = J_{Pr} + J_D$)	$9.252 \times 10^7 mg/yr$
17	Total Campground Site Units (U)	40 units
18	Mean Persons/Unit (P)	1.39 persons/unit
19	Mean Season Length (SL)	85 days
20	Campground Capita Years ($N_{CY}' = [U \cdot P \cdot SL]/365$)	12.98 capita years
21	P Contribution per Capita (S)	0.48 Kg/cap.yr.
22	Sewage Treatment Retention Coefficient (R_S)	0.01
23	P Contribution from Campground ($J_A' = S \cdot N_{CY}' [1 - R_S]$)	6.17 Kg
24	Number of Cottages (N_C)	289 units
25	Number of Permanent Dwellings (N_D)	6 units
26	Capita Years per Cottage (P_C)	0.63 capita years
27	Capita Years per Dwelling (P_D)	4.3 capita years
28	Total Occupant Capita Years ($N_{CY}'' = P_C \cdot N_C + P_D \cdot N_D$)	207.87 capita years
29	P Contribution per Capita Year (S')	0.80 Kg/cap.yr.
30	Contribution from Dwellings&Cottages [$J_A'' = S' \cdot N_{CY}'' (1 - R_S)$]	164.63 Kg
31	Total P from Artificial Sources ($J_A = J_A' + J_A''$)	170.80 Kg/yr
32	Total P Supply ($J_T = J_N + J_A$)	263.32 Kg/yr
33	Predicted Spring Total P Concentration ($P = [J_T(1-R)]/Q$)	0.01585 mg/L

Steps 1, 2 & 3:

Measurement of lake surface area and estimations of lake volume and mean depth are standard limnological procedures (Welch, 1948). Measurements for Gull Lake were conducted during November, 1978 by Water Standards and Studies staff. Surface area was measured with an Alpha p-27 polar planimeter on a 1:50,000 NTS map, #62I/7. A Furuno Mark IV unit was used for echo sounding. Gull Lake morphometry is presented in Appendix I.

Step 4:

Estimation of the gross drainage basin area is a standard hydrological procedure (Gray, 1970) wherein the high points of land surrounding the lake are outlined on a topographic map. It is assumed that both surface water and groundwater flow downhill as indicated by topographic contour lines. The gross drainage area for Gull Lake was outlined on a 1:50,000 scale NTS map #62I/7 and the surface area measured by planimetry. The surface area of Gull Lake itself (i.e Ao) was excluded from the calculation. The watershed was not segregated by landuse type as recommended by Hough, Stansbury and Michalski Limited (1980) since that of Gull Lake is remarkably homogenous.

Step 5:

Mean annual precipitation was extracted from Weir (1983).

Step 6:

Estimation of net annual runoff is a standard hydrological procedure (Gray, 1970). The Gull Lake watershed has no

surficial runoff because of the porosity of the sandy soil (D. Donachuk, pers. comm.*). Hence, the lake is recharged by groundwater infiltration (Ibid). An estimate of the rate of groundwater discharge to Gull Lake might be obtained from mean annual precipitation less mean annual potential evapotranspiration. Using the values provided by Weir (1983), net annual runoff from the Gull Lake watershed could be estimated at (0.500 m/yr - 0.440 m/yr = 0.060 m/yr). However, the soil porosity of the watershed suggests that soil infiltration of precipitation is very rapid and that the rate of potential evapotranspiration cited is an overestimation. Hence, an alternate process of estimation was required. The nearest metered watershed with a substantial sandy soil component was that of the Brokenhead River between Vivian and Beausejour. Using values provided by Water Resources Branch (1983) for meter stations 05SA002 and 05SA004, net annual runoff was calculated at 0.115 m/year. The latter value for r was selected (i.e. r = 0.115 m/year rather than r = 0.060 m/yr) since potential overestimation of natural inflows corresponds to a potentially more conservative estimate of artificial phosphorus loadings.

Step 7:

An estimate of the rate of mean annual evaporation was not available for Gull Lake. A mean of estimates provided by Mudry**

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* D. Donachuk, Supply and Conservation Engineer, Water Resources Branch, Manitoba Natural Resources.

** M. Mudry, P. Eng. Director of Planning, Water Resources Branch, Manitoba Natural Resources.

(pers. comm.) for several small lakes of Southwestern Manitoba (Appendix II) was adopted.

Steps 8, 9 & 10:

These calculations are standard load estimation procedures (Hough, Stansbury & Michalski Limited, 1980).

Step 11:

The empirical formula for estimating the relative amount of phosphorus unavailable for dispersion through the water column was provided by Dillon (no date) in Hough, Stansbury and Michalski Limited (1980). The equation replaces that proposed by Dillon and Kirchner (1975).

Steps 12 & 13:

Atmospheric contribution of phosphorus can be very significant in lakes with small drainage basins (Schindler et al, 1976). Values reported by Schindler et al (1978) ranged from 24 to 53 mg/m^2/year for the Experimental Lakes Area near Kenora, Ontario. Experimental measurements of aeolian phosphorus contributions conducted near Brandon, Manitoba (Appendix III) indicated loading rates up to 82 mg/m^2/year (M. Bennett, pers. comm.*). Considering the values reported for the Experimental Lakes Area, it was deemed not

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* M. Bennett, Special Projects Coordinator, Air Standards and Studies Section, Manitoba Environment and Workplace Safety and Health.

unreasonable to adopt the arithmetic mean of the Brandon values (i.e 41 mg.m^2/year) for the present study. Estimation of the total atmospheric contribution is then a simple calculation of the rate per square metre multiplied by total surface area of the lake.

Steps 14 & 15:

Phosphorus export coefficients typically are estimated on the basis of stream discharge and concentrations of phosphorus in the stream (Dillon and Kirchner, 1975). However, Gull Lake is not recharged by stream flows and a stream suitable for estimation of export coefficients does not occur near the study area. Since Gull Lake is recharged primarily by groundwater infiltration, the export coefficient could be derived from data for local surficial wells. Hence, the mean phosphorus concentration from two local wells situated beyond the possible zone of influence from the Gull Lake cottage development (i.e wells #149 and #283, in Beck and Brown, 1985) was considered representative of natural, unimpacted groundwater in the watershed. The mean, 15 mg/m^2/year, was near the upper limit for the coefficients from forested sedimentary watersheds in southern Ontario (i.e. 6.7 to 18.3 mg/m^2/year) reported by Dillon and Kirchner (1975). The total natural phosphorus contributed by the watershed was then estimated by the export coefficient multiplied by total area of the drainage basin.

Step 16:

Hough, Stansbury and Michalski Limited (1980) calculations include phosphorus supplied from upstream sources. Since Gull Lake receives no stream inflows, the total phosphorus supply from natural sources may be estimated by summing contributions from the drainage basin outflow (i.e. groundwater) and from the atmosphere.

Step 17:

This estimate of the maximum number of camping sites occupying the private northwest shore campground facility was provided by D. Minty (pers. comm.).

Step 18:

An estimate of the mean number of persons per camping unit was not available for either Gull Lake or Manitoba in general. The present estimate was derived from the Hough, Stansbury & Michalski Limited (1980) mean of 4.30 capita years at permanent homes, multiplied by 0.324, the mean Eastern Region campsite occupancy ratio (Manitoba Natural Resources, 1985). Although the mean campsite ratio may be somewhat high for the Gull Lake campground, its present use is justified as a way of accounting for loadings due to beach day users.

Steps 19 & 20:

Water Standards and Studies estimated the 1985 season length on the basis of weekends from May 5 to June 21, and daily thereafter to September 2 (inclusive). Tourist capita years were then calculated with the Hough, Stansbury and Michalski Limited (1980) formula.

Step 21:

A variety of estimates for phosphorus contributions per capita are available. Because of the nature of the Gull Lake campground, our estimate needed to be indicative of a relatively undeveloped facility (e.g. no hot showers). Therefore, Scheider's (1978) estimate, developed for Algonquin Park, was adopted.

Step 22:

Human wastes generated at the Gull Lake campground are discharged to pit privies located on site. (Note that self contained units are considered an exception in this instance). Since the soil is sandy in nature, the Brandes et al (1974) coefficient for phosphorus retention in sand was adopted.

Step 23:

The Hough, Stansbury and Michalski Limited (1980) formula was used to estimate the total phosphorus contributed by campground patrons.

Steps 24 & 25:

Counts were provided by D. Minty (pers. comm).

Steps 26, 27 & 28:

The absence of specific data for Gull Lake necessitated adoption of the values and formula of Hough, Stansbury and Michalski Limited (1980).

Step 29:

Because a relatively longer term of occupancy in cottages implied a greater incidence of intensive phosphorus loading activities such as dishwashing, as compared to campers, the phosphorus loading rate adopted for step #21 was not suitable for application to cottage loadings. Hence, the value recommended by Hough, Stansbury and Michalski Limited (1980) has been adopted.

Steps 30, 31, 32 & 33:

Calculations were performed according to formulae presented by Hough, Stansbury and Michalski Limited (1980).

2.3.1 Model Validation

Model validity may be assessed either by actual observation or by theoretical means. Since temporal constraints prevented actual measurement of spring phosphorus concentrations over a series of years, actual observations could not be used for model validation. Hence, for the purposes of the present study, model validation could be achieved only by calculations drawn from the literature. The process involves algebraic manipulation of established formulae in order to isolate the spring phosphorus concentration as a variable. The equation is then solved by substitution of measured values for remaining variables.

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* [Chla] and [TP] are expressed as mg/m^3

The classic equation defining the summer chlorophyll a concentration ([Chla]) to spring total phosphorus concentration ([TP]) relationship in north temperate lakes developed by Dillon and Rigler* (1974) was:

$$\text{Eq. 1:} \quad \log_{10}[\text{Chla}] = 1.449 \log_{10}[\text{TP}] - 1.136$$

The equation may be manipulated to isolate the [TP] variable as follows:

$$\text{Eq. 1a:} \quad \log_{10}[\text{TP}] = (\log_{10}[\text{Chla}] + 1.136)/1.449$$

Substitution of the [Chla] variable by 5.1 (from Table 2) and solving equation 1(b) predicted a [TP] of 18.72 mg/m^3.

A second equation defining the [Chla]-[TP] relationship in north temperate, shallow mixed lakes was very recently developed by Riley and Prepas (1985). This equation was:

$$\text{Eq. 2:} \quad \log_{10}[\text{Chla}] = 1.251 \log_{10}[\text{TP}] - 0.680$$

The equation may be manipulated to isolate the [TP] variable as follows:

$$\text{Eq. 2(b):} \quad \log_{10}[\text{TP}] = (\log_{10}[\text{Chla}] + 0.680)/1.251$$

Substitution of the [Chla] variable by 5.1 (from Table 2) and solving equation 2(b) predicted a [TP] of 12.86 mg/m^3.

Chlorophyll a concentrations increase as the percentage of a lake's total volume infested with aquatic macrophytes decreases (Canfield et al, 1984). The pertinent inference is that relationships defined by data drawn from a combination of stratified and mixed lakes, such as that of Eq. 1, may tend to overestimate [Chla] in lakes which are not well mixed. While Gull Lake is of insufficient depth to maintain thermally stratified conditions, the significant growths of macrophytes may inhibit wind induced mixing action (Ibid). Given these inferences, one might expect that a measured [TP] would lie somewhere between the values predicted by Eq. 1 and Eq. 2. The estimated phosphorus budget [TP] (Table 1) was 0.01585 mg/L (equivalent to 15.85 mg/m^3), nearly midway between the two predicted [TP] values. Thus the phosphorus budget developed for Gull Lake was considered valid.

3.0 DISCUSSION

A summary of Gull Lake water quality characteristics is presented in Table 2. Detailed physicochemical results and station statistical summaries are presented in Appendices IV and V, respectively.

3.1 Identification of the Problem Nutrient

A nutrient will be consumed by aquatic vegetation at a rate proportional to the need for that nutrient (Rast and Lee, 1978). Hence the growth of aquatic vegetation is limited by the nutrient which is available to it in the minimal quantity relative to its needs for growth or reproduction (Ibid). The nutrient most likely to limit productivity can be revealed by a "demand:supply" ratio (Vallentyne, 1974). Alternately, the nutrient which is present in large quantities during periods of excessive aquatic vegetation growths is not limiting growth of macrophytes (Rast and Lee, 1978).

The demand:supply ratio may be quantified on the basis of actual vegetational requirements. The atomic ratio of nitrogen:phosphorus (i.e N:P) present in plankton averaged 16:1 (Redfield et al, 1963; in Rast and Lee, 1978). The atomic ratio for algae common to ponds and lakes in the south-eastern United States averaged 24:1 (Rast and Lee, 1978). Converting the atomic ratios to mass or weight (atomic weight of nitrogen = 14.01; atomic weight of phosphorus = 30.97), yields a mass N:P ratio of 7.24 mg N:1 mg P for plankton and 10.86 mg N:1 mg P for algae, respectively. This meant that N:P mass ratios less than the 7.24 to 10.86 range indicated

TABLE 2: SUMMARY OF GULL LAKE PHYSICOCHEMISTRY

Parameter		Mean ± Standard Deviation ($\bar{x} \pm \sigma$)	
		Summer (N = 142)	Fall + Winter (N = 12)
Conductivity	(µS/cm)	684.7 ± 16.14	702.5 ± 54.07
Total Residue	(mg/L)	498.3 ± 57.66	496.7 ± 29.02
Filterable Residue	(mg/L)	491.8 ± 47.17	496.7 ± 29.02
Non Filterable Residue	(mg/L)	< 8.3 ± 31.7	< 5.0 ± 0
pH	(units)	9.04	9.07
Alkalinity	($mgCaCO_3/L$)	379.2 ± 5.91	403.3 ± 35.02
Alkalinity	($mgHCO_3/L$)	356.3 ± 20.90	380.7 ± 46.64
Alkalinity	($mgCO_3/L$)	52.3 ± 10.67	51.9 ± 7.59
Calcium	(mgOH/L)	0.0 ± 0	0.0 ± 0
Magnesium	(mg/L)	15.8 ± 3.18	14.5 ± 0.92
Hardne s	(mg/L)	83.2 ± 4.66	87.5 ± 4.28
Iron	($mgCaCO_3/L$)	382.7 ± 41.46	396.4 ± 20.76
Potassium	(mg/L)	0.053 ± 0.214	0.024 ± 0.007
Sodium	(mg/L)	15.7 ± 1.09	16.9 ± 0.68
Dissolved Oxygen	(mg/L)	27. ± 1.44	28.0 ± 1.05
Turbidity	(mg/L)	8.97 ± 1.30	8.14 ± 0.92
Silicon Dioxide	(NTU)	2.03 ± 8.35	0.87 ± 0.27
Total Kjeldhal Nitrogen	(mg/L)	1.72 ± 1.06	2.92 ± 0.13
Ammonia	(mg/L)	1.78 ± 0.161	1.86 ± 0.08
Nitrate-Nitrite	(mg/L)	0.01 ± 0.011	0.06 ± 0.06
Total Phosphorus	(mg/L)	0.02 ± 0.049	0.01 ± 0.01
Chloride	(mg/L)	0.022 ± 0.009	0.013 ± 0.003
Sulphate	(mg/L)	13.3 ± 1.04	15.1 ± 1.38
Chlorophyll "a"	(µg/L)	20.3 ± 6.48	24.2 ± 6.95
Secchi Disc	(metres)	5.05 ± 5.50	2.74 ± 6.37
		2.37 ± 0.400	1.58 ± 0.98

that nitrogen was the limiting nutrient. Alternately, N:P mass ratios greater than the 7.24 to 10.86 range indicated that phosphorus was the limiting nutrient.

Assuming that all nitrogen and phosphorus present in Gull Lake water during the summer could theoretically be utilized by aquatic vegetation, substitution of values from Table 2 (1.78 mg/0.022 mg) yeilded a theoretical mass N:P ratio of 80.91:1. However, not all of the total nitrogen and phosphorus present are in forms readily available for use by aquatic vegetation. Cowen and Lee (1976) demonstrated that up to 30% of the total phosphorus can be converted to usable phosphorus (i.e. soluble orthophosphate) in about 20 days. Cowen et al (1976) showed that up to 70% of organic nitrogen (i.e. Total Kjeldhal Nitrogen) can be converted to usable forms (ammonia, nitrate and nitrite) in 35 to 50 days. Application of these qualifiers ((1.78 x 0.70)/(0.022 x 0.30)) modified the N:P ratio to yield a potentially available mass N:P ratio of 188.79:1. A third estimation of the mass N:P ratio was derived from Hutchinson's (1957) estimate that 10% of total phosphorus present in natural water is comprised of soluble orthophosphate* (i.e. readily available to aquatic vegetation). Utilizing the sum of ammonia, nitrate and nitrite (Table 1) and the qualified phosphorus ([0.01 + 0.02]/[0.022 x 0.10) yielded a calculated mass N:P ratio of 13.64:1. Since each of

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* The soluble orthophosphate fraction was not determined in the present study because field preservation techniques are cumbersome and even relatively short terms of storage of preserved samples (i.e. <8 days) yield wide fluctuations in analytical results (El-Shaarawi and Neilson, 1984).

the mass N:P ratios (i.e. theoretical, potentially available and calculated) exceeded the critical range discussed previously, it was concluded that phosphorus was the limiting nutrient for Gull Lake. Therefore, all practical methods for control of aquatic vegetation in Gull Lake had to focus upon control of phosphorus.

3.2 Trophic Status

Understanding of aquatic systems can often be enhanced by application of broadly descriptive terms or labels. For example, the terms lake, river and creek serve to readily identify the general characteristics of a waterbody to most members of the public. One of the more scientifically useful terms pertains to the trophic status, or degree of enrichment and productivity* of a particular waterbody. Three terms are generally used. Oligotrophic refers to unenriched waters of low productivity, mesotrophic refers to moderately enriched waters with moderate productivity and eutrophic refers to very enriched waters which are very productive. Fish kills and excessive vegetation problems are experienced occasionally in mesotrophic waters. Fish kills become more common and problem growths of vegetation become ever more extensive as water become more eutrophic. Clearly defined limits of demarcation between the trophic levels generally are not encountered. Rather, the characteristics of each gradually meld with that of the next level. Thus oligotrophic waters

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* Within the present report, enrichment refers to nutrient availability and productivity refers to biological mass produced.

bordering on mesotrophy may develop minor algal growths and sparse macrophyte populations. Mesotrophic waters bordering on eutrophy may develop occasional algae blooms and dense macrophyte growths..

A variety of definitive indices or classification schemes have been proposed; four of which have gained general acceptance in North America (Rast and Lee, 1978). Two of the indices, that proposed by US EPA (1974) and Piwoni and Lee (1975), are relatively intensive and involve a number of parameters not considered during the present study. Hence, they were not applicable to Gull Lake. The indices of Vollenweider (1975) and Carlson (1977) were more simplistic and readily applicable to Gull Lake.

Carlson (1977) developed a numerical trophic state index graduated in a scale of 0 to 100. The index number may be calculated from secchi disk transparency, chlorophyll a or total phosphorus (Ibid). The approximate limit of demarcation between eutrophic and mesotrophic states occurs at 50 units and between mesotrophic and oligotrophic states occurs at approximately 30 units (Ibid). The computational forms of the equation * (Ibid) are:

$$\text{Eq. 3.} \quad TSI(SD) = 10\left(6 - \frac{\ln SD}{\ln 2}\right);$$

$$\text{Eq. 4.} \quad TSI(Chl) = 10\left(6 - \frac{2.04 - 0.68\,(\ln Chl)}{\ln 2}\right)$$

$$\text{Eq. 5.} \quad TSI(TP) = 10\left(6 - \frac{\ln\left(\frac{48}{TP}\right)}{\ln 2}\right)$$

---

* Where SD is expressed in metres, Chla is expressed in mg/m^3 and TP is expressed in mg/m^3

Substitution of appropriate values from Table 2 and solving the equations yielded trophic state indices (TSI) for secchi disk (SD) of >47.6, (TSI) for chlorophyll (Chl) of 46.5, and (TSI) for total phosphorus (TP) of 48.7. Application of the calculated TSI values to Carlson's (1977) scale suggested that Gull Lake is mesotrophic bordering on eutrophic.

Vollenweider's (1975) scale (Figure 2) considered a logarithmic relationship between phosphorus loading and mean depth/hydraulic residence time. The process involves plotting phosphorus loading ($gP/m^2/yr$) versus mean depth/hydraulic residence time (i.e. qS from Table 1). Solving for the variables with appropriate values from Tables 1 and 2 (phosphorus loading = 2.6332×10^5 g/$1.176 \times 10^6 m^2$ = 0.22, qS = 0.674) indicated that Gull Lake was eutrophic bordering on mesotrophic (Figure 2).

3.3 Long Term Prognosis Assuming No Phosphorus Control

Lakes are a relatively short lived phenomenon when viewed from a geological time scale (Welch, 1935). They undergo a natural aging process wherein they are slowly but continuously filled in (Ibid). As the filling-in process continues, lakes become more and more eutrophic (Reimer, 1984). Man's activities within the watershed can greatly accelerate the natural process of eutrophication (Ibid). This means that the progression of natural eutrophication as compared to that accelerated by man's activities will be similar; but that the rate or speed of the respective progressions may differ greatly.

Assuming that no attempt is made to control nutrient inputs to Gull Lake and that nutrient loadings shall therefore remain constant,

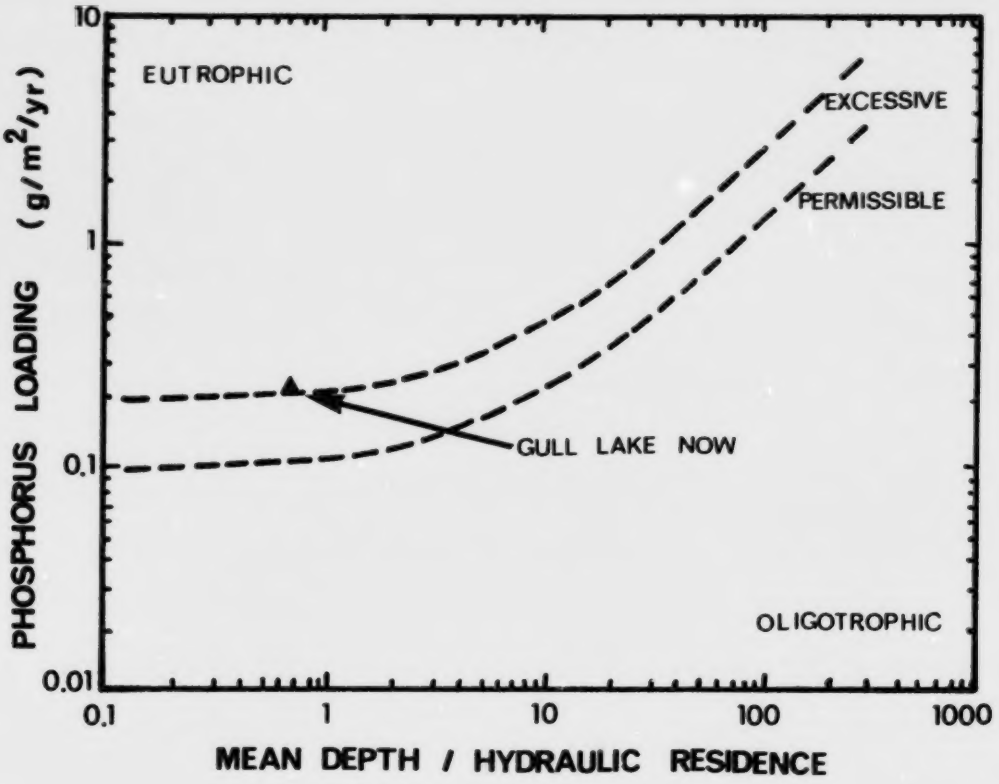

FIGURE 2: Vollenweider's (1975) trophic state scale.

one might intuitively expect total nutrient concentrations in the lake to increase over time. This is because the lake is flushed approximately once every 4.93 years (1/p; Table 1) rather than annually and because certain nutrient fractions become trapped in the sediments and undecomposed vegetation fragments (Reimer, 1984). The increased supply of nutrients causes further vegetation growth (Ibid.) Applying these principles to Gull Lake, one might expect that the rooted macrophytes will continue to proliferate and significantly expand the current area/volume of infestation. This will compound the problems currently experienced by boaters, swimmers, anglers and owners of waterfront property.

However, as has been discussed, phosphorus at present is the nutrient in shortest supply (i.e. the limiting nutrient) in Gull Lake. As phosphorus concentrations continue to increase, the vegetational demands made upon the available nitrogen will also increase (Rast and Lee, 1978). Additionally, bacterial processes for decomposition of vegetation will consume large supplies of nitrogen (Vollenweider, 1975). This means that the N:P ratio will decline; ultimately to the point where nitrogen becomes the limiting nutrient (Rast and Lee, 1978). When nitrogen supplies become deficient, a change in the type of plants present will occur (Vollenweider, 1975). Plants able to survive in low nitrogen water and especially those capable of "fixing" atmospheric nitrogen (i.e. the cyanophytes or blue-green algae) will gradually begin to dominate (Ibid). It is the cyanophytes that are most often associated with algae blooms and the resultant obnoxious odors and fish kills.

Attempting to predict a time frame for the rate of progression of eutrophication in Gull Lake is not yet feasible. This is because the science is still imperfect and appropriate models have not been developed. However, it was noted that a substantial bloom of the cyanophyte Anabaena flos-aquae did develop during late July-early August, 1985. This development confirmed the onset of eutrophic status. It is expected that similar blooms would occur ever more frequently and last for ever extending durations. Odor problems are anticipated from such occurrences.

3.4 Phosphorus Control

Since phosphorus is the limiting nutrient in Gull Lake, and because aquatic vegetation will proliferate to the limit of nutrient availability, reducing the supply of phosphorus effectively starves the aquatic vegetation of essential nourishment (Rast and Lee, 1978). In order to reduce the phosphorus supply, it is essential to identify and quantify the sources. The sources which are amenable to control must be determined. Generally little can be done about natural sources, therefore, the attention must focus on artificial sources.

The natural and artificial phosphorus sources to Gull Lake have been identified and quantified (Table 1). It was determined that phosphorus from artificial sources accounted for 64.9% of the total phosphorus supply to Gull Lake (Table 3). The bulk of the total supply, 54.8% (84.4% of the artificial supply), was derived from the cottages. Lesser proportions of the total supply were attributable to

TABLE 3: ITEMIZATION OF THE ARTIFICIAL PHOSPHORUS COMPONENT

PARAMETER		ARTIFICIAL SOURCE			
		Campground	Dwellings	Cottages	Total
Total P	(kg)(1)	6.17	20.43	144.20	170.80
% of Artificial P	(%)(2)	3.6	12.0	84.4	100
% of Total P	(%)(3)	2.3	7.8	54.8	64.9
Predicted Spring P minus P_{AX}	(mg.L)(4)	0.01546	0.01458	0.00693	0.00528
Predicted Summer P minus P_{AX}	(mg/L)(5)	0.0215	0.0202	0.0096	0.0073
Predicted Carlson TSI [P]	(6)	48.4	47.5	36.8	32.8
Predicted Vollenweider Loading	($g/m^2/yr$)(7)	0.21	0.20	0.10	0.07

(1) Extracted and or calculated from Table 1.

(2) Calculated as $(P_A-P_{AX})/P_A$;

Where P_A = Total artificial phosphorus
P_{AX} = Artifical phosphorus from a specific source

(3) Calculated as $(P_A - P_{AX})/P_T$;

Where P_T = Total phosphorus

(4) Calculated as per Step 33, Table 1;

With J_T = $P_T - P_{AX}$

(5) Calculated as $P_{PS} = P_{pp} \times (P_{GO}/P_{GP})$;

Where P_{PS} = predicted summer phosphorus
P_{PP} = predicted spring phosphorus
P_{GO} = Gull Lake observed mean summer phosphorus
P_{GP} = Gull Lake predicted spring phosphorus

(6) Calculated as per Equation 5, with TP = P_{PS}

(7) Calculated as $L - (P_T - P_A)/A_O$;

Where L = phosphorus loading in $g/m^2/yr$

the permanent residences (7.8%) and to the campground (2.3%).

Spring phosphorus concentrations were predicted (Table 3) for each case where one artificial source was completely eliminated. Since predicted phosphorus concentrations were a function of calculated supply, the results were similar. This meant that the greatest individual reduction was predicted for the scenario in which the phosphorus supplied by cottages was eliminated.

Carlson's (1977) TSI [P] index was calculated on the basis of mean summer phosphorus concentrations. Hence, predicted summer phosphorus concentrations were required in order to determine TSI [P] for each source reduction scenario (i.e. Step 5, Table 3). Since an appropriate model for the prediction of summer phosphorus concentrations has not been developed, an estimation procedure was derived from comparing the current observed mean summer phosphorus concentration in Gull Lake (i.e. 0.022 mg/L; Table 2) to the current spring prediction (i.e. 0.01585 mg/L; Table 1). The ratio (0.022/0.01585 = 1.39) was considered appropriate for estimating predicted summer phosphorus concentrations from the spring phosphorus concentrations which were predicted for various source control scenarios. A significant change in trophic status (i.e. TSI [P]) was predicted for only those scenarios in which phosphorus supply was reduced by eliminating either the cottage source or all artificial sources (Figure 3).

Application of Vollenweider's (1975) scale yielded similar results. Conversion of Gull Lake to the lower mesotrophic state could only be achieved by eliminating either the cottage source or all artificial sources (Figure 4).

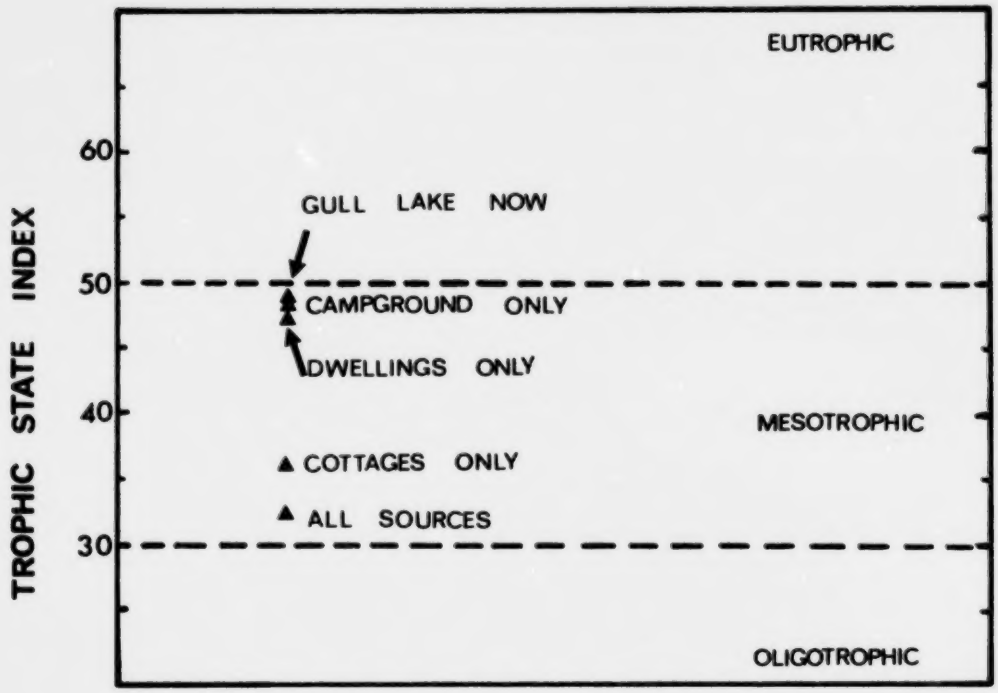

FIGURE 3: Carlson's (1977) predicted TSI for Gull Lake with different artificial phosphorus sources controlled.

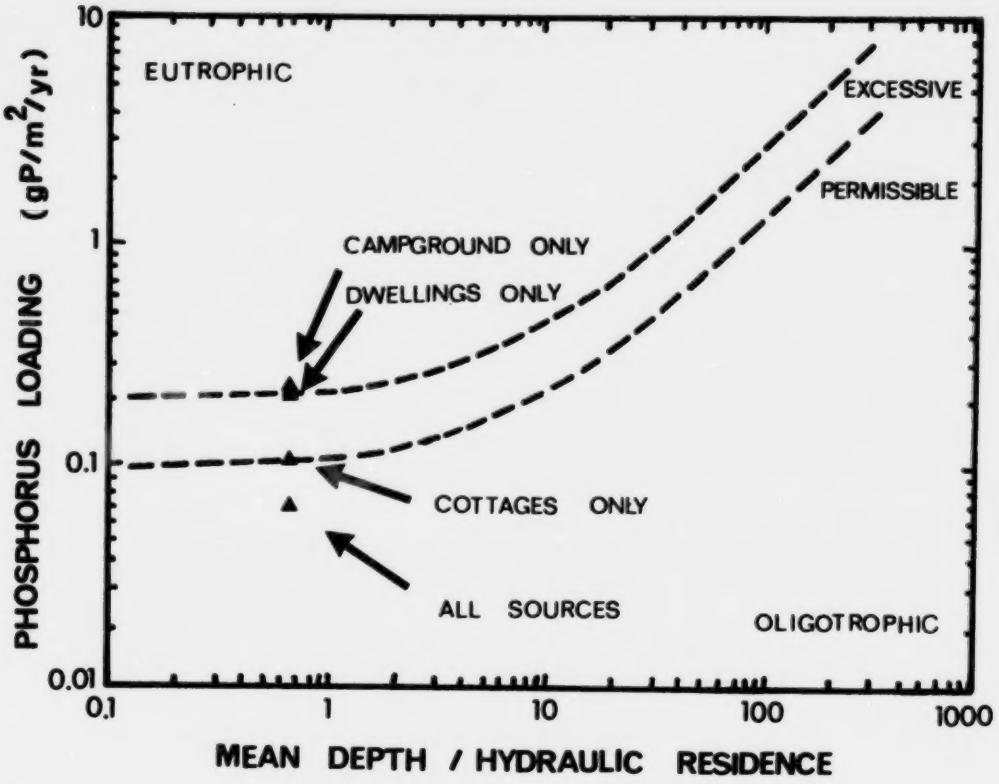

FIGURE 4: Vollenweider's (1977) predicted P loading for Gull Lake with different artificial phosphorus sources controlled.

Elimination of artificial phosphorus sources can be achieved through the proper installation and maintenance of holding tanks to which all sewage and wastewaters are directed (Hough, Stansbury and Michalski Limited, 1980). Given the sandy nature of the Gull Lake watershed, successful source elimination would be contingent upon exporting or trucking the holding tank wastewaters entirely out of the Gull Lake watershed.

3.5 Long Term Prognosis Assuming Phosphorus Control

Significant improvement in Gull Lake trophic status requires conversion of the present eutrophic-bordering-mesotrophic status to mesotrophic-bordering-oligotrophic status. This can be achieved by either eliminating the cottage source of phosphorus or all artificial sources of phosphorus. It would not be possible to improve the trophic status further (i.e. to the oligotrophic state) since full oligotrophic status would not be normal for Gull Lake were it solely in a "natural" state (Rast and Lee, 1978; Hough, Stansbury and Michalski Limited, 1980). The following prognosis assumes that phosphorus control has been achieved by eliminating either the cottage source or all artificial sources.

Were phosphorus control to be achieved immediately, conversion to the mesotrophic-oligotrophic state would not be instantaneous. Lake Washington, located near Seattle, Washington, had a flushing rate similar to Gull Lake and also received a large proportion (57%) of its phosphorus supply from artificial sources (Carlson, 1977). When phosphorus control was achieved for

Lake Washington, chlorophyll showed immediate improvement while there was a three year lag before secchi disk transparencies improved (Ibid). However, the Lake Washington problem was algae blooms (Ibid) whereas the problem of Gull Lake consists of excessive growth of rooted macrophytes. Neel (1975) showed that algal response to phosphorus control was modified, primarily due to rooted macrophytes. Rast and Lee (1978) suggested that the discrepancy was due to nutrients obtained through the macrophyte root systems in the sediments. Thus phosphorus residence time (P_{Tw}) models such as that of Sonzogni et al (1976) which generally predict a P_{Tw} of approximately 1/3 the hydraulic residence time, could not be applied to Gull Lake.

The author has been unsuccessful in locating a model estimating phosphorus residence time in sediments from the literature. Therefore, a rough estimation was empirically derived by factoring the current sediment phosphorus supply (expressed as unity) by the lake retention coefficient (R = 0.951) until the sediment supply was reduced to approximately 50% of unity. The 50% of unity value was determined to occur at approximately 14 years. This was considered equivalent to Sonzogni et al's (1976) state of equilibrium at which 95% of the expected change in phosphorus content would have occurred following control. This meant that the maximum benefit from eliminating either the cottage phosphorus source or all artificial phosphorus sources would not be experienced until approximately 14 years had elapsed from the date at which control had been achieved.

Assuming phosphorus control had been achieved and that a state of equilibrium had become established, the characteristics of Gull Lake would be similar to that extant prior to the occurrence of excessive development. This means that the occasional fish die-off attributable to mid winter oxygen depletion will still occur on an infrequent basis. Additionally, the extent of rooted macrophytes would be substantially reduced although they would not entirely disappear. An improvement in water transparency due to a decline in chlorophyll levels will be offset due to murkiness induced by wave action. In fact, it is probable that wind induced wave action will actually increase turbidity significantly over current transparency since macrophytes reduce wind mixing and suspension of bottom sediments (Canfield et al, 1984). Considered in total, the present problems caused by excessive growth of macrophytes and experienced by recreationers at Gull Lake, would be substantially reduced.

4.0 CONCLUSIONS

It was concluded that:

1. The trophic status of Gull Lake was borderline between mesotrophy and eutrophy.
2. Phosphorus was the limiting nutrient in Gull Lake.
3. Artificial phosphorus sources accounted for approximately 64.9% of the total phosphorus loading to Gull Lake.
4. Among the artificial phosphorus sources, cottages contributed approximately 54.8%, permanent residences contributed approximately 7.8% and the campground contributed approximately 2.3% of the total phosphorus loading to Gull Lake.
5. A significant reduction in the accelerated rate of eutrophication could be achieved by control of artificial phosphorus sources.
6. Assuming total control of the artificial phosphorus sources, it is estimated that the trophic status of Gull Lake could be improved to a state of mesotrophy bordering oligotrophy within a period of approximately 14 years.

5.0 ACKNOWLEDGEMENTS

The present study could not possibly have occurred without the collection of field samples during the summer season. This essential contribution by Mr. Don Minty and Mr. Carl Klassen, both executive members of the Gull Lake Ratepayers Association, is very gratefully acknowledged. Analysis of samples by staff of the W. M. Ward Technical Services Laboratory is also greatly appreciated.

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APPENDIX I

GULL LAKE MORPHOMETRY, NOVEMBER, 1978

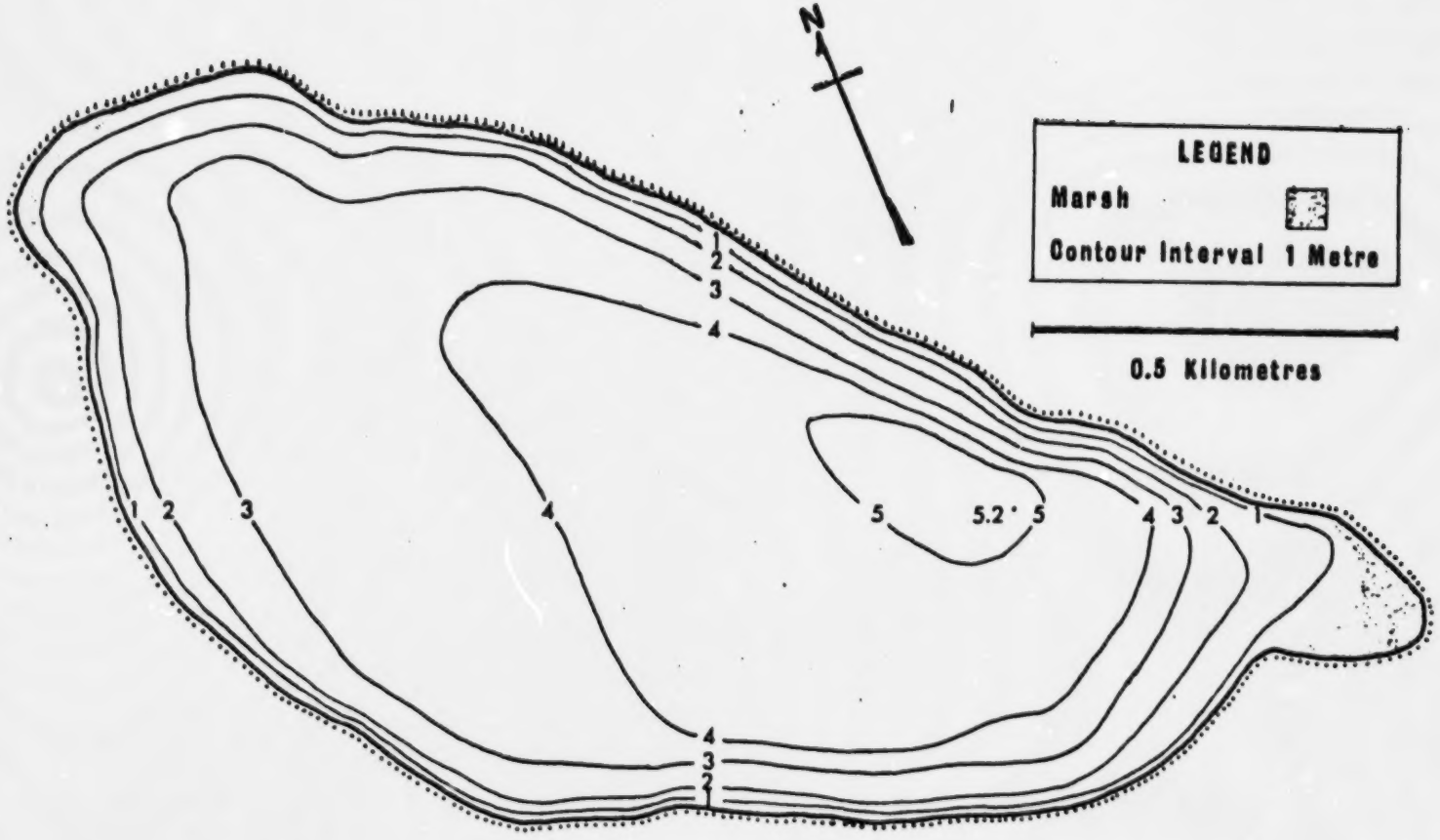
Lake Level on November 3, 1978	253.71 metres (832.37 feet)
Gauge "0" set	253.28 metres (830.97 feet)

Area per contour and volume between contours

Contours (metres)	Area (square metres)	Volume (cubic metres)
0 (surface area)	1,176,089	
		1,131,984
1	1,088,444	
		1,028,661
2	970,015	
		867,660
3	769,183	
		638,354
4	515,925	
		231,863
5	38,580	
		2,585
5.2 spot depth)	1	

Total Volume (V)	3,901,107 cubic metres
Surface Area (A)	1,176,089 square metres
Mean Depth (V/A)	3.32 metres
Maximum Length of open water (L)	2.014 kilometres
Maximum Width (Perpendicular to L)	0.873 kilometres
Mean Width (A/L)	0.584 kilometres

Secchi disc at 5.2 metre spot depth (November 2, 1978) 3.66 metres



Gull Lake

50°24'N 96°31'W

November, 1978

MANITOBA

Inter-Departmental Memo

PS 1 25

Date January 18, 1980

To Mr. Grant McLeod
Director of Environmental Control Branch
Environmental Management Division
139 Tuxedo Avenue

From N. Mudry, P.Eng.,
Director of Planning
Water Resources Branch
1577 Dublin Avenue

File: 4.3.2

Telephone

Subject Information on Selected Manitoba Lakes

First | Fold

Further to your memoranda of June 13 and July 24, 1979 requesting information on a number of Manitoba lakes please find the following:

1. An estimate of annual runoff, annual net evaporation over the lake, gross basin drainage area and lake surface area has been prepared for each of the lakes and is summarized in Table 1.

2. Recorded water level information for Thomas, Sharpe and Dromore Lakes.

3. Copies of the maps showing the delineation of the drainage area contributing to each lake will be forwarded when drafting has been completed.

If any questions should arise, please contact Mr. D. Donachuk at 786-9396.

N. Mudry

Attachments

TABLE 1

METEOROLOGICAL AND SURFACE AREA INFORMATION

	SUBJECT	GROSS DRAINAGE AREA IN SQ. KM.	LAKE SURFACE AREA IN SQ. KM	ANNUAL NET EVAPORATION OVER LAKE IN MILLIMETERS					ANNUAL RUNOFF IN MILLIMETERS				
				CALCULATED			ESTIMATED 100 YEAR EXTREME		CALCULATED			ESTIMATED 100 YEAR EXTREME	
				MEAN	MAX.	MIN.	MAX.	MIN.	MEAN	MAX.	MIN.	MAX.	MIN.
1	THOMAS LAKE	23	2	-130	31	-540	175	-550	51	102	8	203	3
2	PARTRIDGE LAKE	4	0.3	-100	218	-470	275	-525	51	89	13	191	3
3	SHARPE LAKE	43	2	- 70	238	-440	320	-500	43	76	10	165	3
4	DROMORE LAKE	56	0.6	- 85	228	-455	300	-500	46	79	10	165	3
5	ECHO LAKE	77	9	- 70	190	-464	300	-480	127	178	25	229	13
6	NUMBO LAKE	78700	4	- 70	190	-464	300	-480	211	373	89	381	76
7	HORSESHOE LAKE	14	4	- 70	190	-464	300	-480	127	191	25	229	13
8	MEDITATION LAKE	6	2	- 70	190	-464	300	-480	127	203	25	241	13
9	MUD TURTLE LAKE	10	2	- 70	190	-464	300	-480	114	191	25	229	13
10	GEORGE LAKE	86	13	- 50	200	-450	325	-470	127	178	25	229	13
11	CHOMDUCK LAKE	106	35	- 41	219	-440	350	-460	127	178	25	229	13

Manitoba

Memorandum

Date January 13, 1986

To Al Beck
Env. Officer
Water Standards and Studies

From Mark Bennett
Special Projects Coordinator

Telephone

Subject YOUR REQUEST FOR INFORMATION/DATA ON DRY DEPOSITION OF PHOSPHORUS

1) BACKGROUND

I shall not go into a lot of detail here about dry deposition mechanisms. To be perfectly honest, I cannot claim perfect understanding of the phenomenon. However, basically, the process of deposition (net flux) is defined by the following equation;

flux (mass/area/time) = Aerosol concentration (mass/volume*) X deposition velocity (length*/ time)

* the units for length and volume should be the same.

The deposition velocity when calculated involves several variables, including i) Particle or gas
ii) Physical characteristics (i.e., particle size distribution)
iii) Chemical characteristics (solubility, reactivity etc)
iv) Receptor surface characteristics
v) Meteorological conditions (most importantly wind speed)

On Wednesday, January 8, I spoke to Len Barrie (of Atmospheric Environment Service), who is an expert, and he estimated that the deposition velocity for Phosphate (PO_4) would not be much different than Sulphate (SO_4). Thus, velocities would range from about .1 to 2 cm/sec. Taking particle size distribution into account our best bet would be about .8 cm/sec.

From the data, obtained in Brandon and provided by Don Regehr we find the following;
i) Range of air phosphate concentrations = 0.01 - 0.4 $\mu g/m^3$
ii) Geometric mean concentration = 0.02 $\mu g/m^3$ (n= 18)
NOTE: The distribution of air-borne particulate concentrations is log-normal and, therefore, a geometric mean as opposed to an arithmetic mean, is calculated.
iii) Sampling took place between June 6 - October 4, 1985 and thus occurred during the open-water season.

../2

Al Beck
Page 2
January 13, 1986

2) PREDICTED DEPOSITION LEVELS

The following values represent the predicted dry deposition amounts, based upon the information above.

		PO_4	P*
Minimum value of annual deposition	=	0.9 $mg/m^2/yr.$	0.3 $mg/m^2/yr.$
Maximum value of annual deposition	=	250 $mg/m^2/yr.$	82 $mg/m^2/yr.$
Mean value of annual deposition	=	5.0 $mg/m^2/yr.$	1.6 $mg/m^2/yr.$

P* - Phosphorus concentrations = Phosphates (PO_4) X 0.326

I hope this information is suitable for your purposes and meets your requirements.

Mark Bennett

MB/lp

cc: D. Regehr
D. Bezak

APPENDIX IV (a):

STATION WQ0934, SOURCE - GULL LAKE
SAMPLING LOCATION - E END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

DATE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
85 06 06	677.0	500.	500.	5. L	8.90	374.	378.	38.	0.
85 06 09	694.0	460.	460.	5. L	8.90	374.	383.	36.	0.
85 06 12	685.0	490.	490.	5. L	9.05	372.	371.	41.	0.
85 06 16	---	---	---	---	---	---	---	---	---
85 06 19	680.0	510.	510.	5. L	8.90	382.	383.	41.	0.
85 06 23	701.0	490.	490.	5. L	9.00	376.	386.	36.	0.
85 07 01	697.0	510.	510.	5. L	8.95	378.	383.	38.	0.
85 07 04	680.0	540.	540.	5. L	8.95	378.	368.	46.	0.
85 07 07	696.0	500.	500.	5. L	9.10	382.	378.	43.	0.
85 07 10	696.0	470.	470.	5. L	9.00	380.	366.	48.	0.
85 07 14	690.0	470.	470.	5. L	8.95	382.	373.	46.	0.
85 07 17	723.0	490.	490.	5. L	9.05	384.	346.	60.	0.
85 07 21	707.0	490.	490.	5. L	9.00	382.	368.	48.	0.
85 07 24	714.0	500.	500.	5. L	9.10	386.	373.	48.	0.
85 07 28	695.0	900.	900.	5. L	9.10	386.	364.	53.	0.
85 07 31	724.0	510.	510.	5. L	9.15	378.	344.	58.	0.
85 08 05	707.0	470.	470.	5. L	9.05	378.	354.	53.	0.
85 08 07	678.0	490.	490.	5. L	9.15	386.	359.	55.	0.
85 08 11	695.0	480.	480.	5. L	9.20	388.	351.	60.	0.
85 08 14	685.0	500.	500.	5. L	9.15	384.	327.	70.	0.
85 08 18	669.0	470.	470.	5. L	9.05	372.	351.	50.	0.
85 08 21	666.0	510.	510.	5. L	9.15	374.	329.	62.	0.
85 08 25	647.0	480.	480.	5. L	9.25	370.	329.	60.	0.
85 09 02	653.0	470.	470.	5. L	9.15	376.	312.	72.	0.
85 10 21	652.0	470.	470.	5. L	9.20	372.	337.	58.	0.
86 01 08	747.0	540.	540.	5. L	9.00	428.	425.	48.	0.

APPENDIX IV (a) cont'd:

STATION WQ0934, SOURCE - GULL LAKE
SAMPLING LOCATION - E END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

DATE	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
85 06 06	15.	73.	339.	0.02	0.02 L	15.	26.	8.0	0.70
85 06 09	16.	79.	368.	0.02	0.04	16.	26.	6.9	1.00
85 06 12	16.	81.	372.	0.02 L	0.03	16.	28.	8.6	1.00
85 06 16	---	---	---	---	---	---	---	---	---
85 06 19	16.	81.	373.	0.02 L	0.02	20.	27.	9.2	1.00
85 06 23	17.	80.	370.	0.02 L	0.04	15.	27.	8.1	1.50
85 07 01	16.	76.	351.	0.02	0.03	15.	25.	5.6	0.90
85 07 04	17.	86.	397.	0.02 L	0.04	16.	28.	8.6	1.00
85 07 07	16.	83.	380.	0.02 L	0.06	15.	26.	7.5	1.50
85 07 10	15.	80.	368.	0.02 L	0.03	15.	28.	8.8	1.50
85 07 14	17.	89.	409.	0.03	0.06	15.	26.	6.5	1.50
85 07 17	16.	84.	386.	0.02	0.02	16.	27.	7.8	1.00
85 07 21	17.	90.	413.	0.02	0.03	16.	30.	7.9	1.00
85 07 24	16.	84.	384.	0.02	0.03	15.	27.	9.3	1.00
85 07 28	16.	82.	377.	0.02	0.02	16.	27.	9.4	1.00
85 07 31	16.	86.	391.	0.02 L	0.04	15.	29.	9.7	1.50
85 08 05	16.	86.	390.	0.02 L	0.02	16.	28.	10.7	1.50
85 08 07	16.	92.	418.	0.02	0.02	15.	31.	8.9	1.50
85 08 11	15.	90.	408.	0.02 L	0.02	16.	28.	9.1	1.50
85 08 14	16.	86.	395.	0.02	0.04	16.	26.	9.1	1.00
85 08 18	15.	84.	380.	0.02	0.06	16.	27.	8.1	1.00
85 08 21	14.	83.	376.	0.02 L	0.03	16.	28.	12.4	1.00
85 08 25	17.	87.	399.	0.03	0.03	15.	27.	9.9	0.75
85 09 02	8.	81.	201.	0.02 L	0.02	15.	25.	8.5	1.50
85 10 21	15.	90.	407.	0.02 L	0.04	17.	29.	8.5	0.90
86 01 08	15.	86.	388.	0.02 L	0.02 L	17.	29.	9.3	1.50

APPENDIX IV(a) cont'd:

STATION HQ0934, SOURCE - GULL LAKE
SAMPLING LOCATION - E END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

DATE	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	SECCHI DISC METRES
85 06 06	0.5	1.60	0.01	0.01 L	0.015	13.	45.	1.8	3.50 G
85 06 09	0.7	1.80	0.01	0.01 L	0.030	12.	23.	2.8	3.50 G
85 06 12	0.6	1.70	0.01	0.01 L	0.025	13.	23.	1.3	2.20 G
85 06 16	---	---	---	---	---	---	---	---	2.50
85 06 19	0.5	1.80	0.01	0.09	0.025	13.	25.	2.3	2.90 G
85 06 23	0.6	1.80	0.01	0.03	0.025	13.	23.	2.6	2.70 G
85 07 01	0.7	1.70	0.01	0.01 L	0.015	14.	25.	2.6	3.20 G
85 07 04	0.7	1.70	0.01	0.07	0.020	14.	14.	7.0	2.40
85 07 07	0.8	1.80	0.01	0.01 L	0.030	13.	14.	4.4	1.90
85 07 10	0.9	1.80	0.02	0.16	0.015	15.	15.	1.3	2.70
85 07 14	1.2	1.70	0.01	0.01 L	0.020	14.	20.	4.4	1.90
85 07 17	1.3	1.80	0.01	0.01 L	0.015	15.	20.	8.3	2.70
85 07 21	1.6	1.70	0.01	0.01 L	0.015	15.	20.	4.4	2.00
85 07 24	1.5	1.80	0.01	0.01 L	0.025	14.	18.	3.5	2.00
85 07 28	2.2	2.00	0.01	0.01 L	0.020	15.	20.	14.0	1.90
85 07 31	2.3	1.90	0.00	0.01 L	0.020	14.	18.	7.0	1.90
85 08 05	2.6	1.80	0.01	0.01 L	0.020	14.	25.	3.5	1.90
85 08 07	2.6	2.00	0.06	0.01 L	0.020	14.	16.	6.1	2.00
85 08 11	2.7	2.00	0.03	0.01 L	0.025	14.	20.	5.8	2.30
85 08 14	3.4	1.60	0.01	0.01 L	0.015	14.	20.	3.1	2.20
85 08 18	3.2	2.20	0.04	0.01 L	0.065	13.	16.	1.8	2.40
85 08 21	3.0	1.80	0.01	0.01 L	0.020	14.	23.	3.9	2.60
85 08 25	2.9	1.50	0.01	0.02	0.015	14.	28.	3.5	3.10
85 09 02	2.8	1.70	0.01	0.04	0.015	14.	20.	3.1	3.00 G
85 10 21	3.0	1.80	0.02	0.01 L	0.015	13.	20.	1.8	---
86 01 08	2.6	1.90	0.05	0.04	0.019	16.	33.	---	---

APPENDIX IV (b)

STATION WQ0935, SOURCE - GULL LAKE
SAMPLING LOCATION - N E END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

DATE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
85 06 06	685.0	530.	520.	12.	9.00	372.	371.	41.	0.
85 06 09	694.0	480.	480.	5. L	8.95	374.	378.	38.	0.
85 06 12	685.0	450.	450.	5. L	8.90	366.	373.	36.	0.
85 06 16	687.0	500.	480.	18.	9.10	380.	386.	38.	0.
85 06 19	680.0	510.	510.	5. L	8.95	380.	376.	43.	0.
85 06 23	701.0	500.	500.	5. L	8.90	382.	388.	38.	0.
85 07 01	697.0	880.	505.	380.	8.85	400.	415.	36.	0.
85 07 04	680.0	500.	500.	5. L	8.90	382.	378.	43.	0.
85 07 07	696.0	500.	500.	5. L	8.95	378.	373.	43.	0.
85 07 10	696.0	470.	470.	5. L	9.10	382.	364.	50.	0.
85 07 14	690.0	470.	470.	5. L	9.10	376.	351.	53.	0.
85 07 17	689.0	500.	500.	5. L	8.90	380.	346.	58.	0.
85 07 21	707.0	490.	490.	5. L	9.10	380.	361.	50.	0.
85 07 24	703.0	500.	500.	5. L	9.05	382.	364.	50.	0.
85 07 28	711.0	480.	480.	5. L	9.05	388.	361.	55.	0.
85 07 31	713.0	520.	510.	6.	9.10	376.	346.	55.	0.
85 08 05	685.0	500.	500.	5. L	9.15	374.	339.	58.	0.
85 08 07	668.0	480.	480.	5. L	9.10	390.	354.	60.	0.
85 08 11	673.0	480.	480.	5. L	9.15	388.	337.	67.	0.
85 08 14	663.0	480.	480.	5. L	9.20	384.	342.	62.	0.
85 08 18	658.0	470.	470.	5. L	9.20	370.	329.	60.	0.
85 08 21	666.0	520.	520.	5. L	9.15	374.	329.	62.	0.
85 08 25	655.0	470.	470.	5. L	9.15	378.	339.	60.	0.
85 09 02	653.0	470.	470.	5. L	9.25	378.	325.	67.	0.
85 10 21	652.0	480.	480.	5. L	9.15	372.	337.	58.	0.
86 01 08	738.0	500.	500.	5. L	8.90	414.	422.	41.	0.

APPENDIX IV (b) cont'd

STATION WQ0935, SOURCE - GULL LAKE
SAMPLING LOCATION - N E END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

DATE	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
85 06 06	16.	74.	344.	0.04	0.06	15.	26.	8.4	2.50
85 06 09	17.	84.	390.	0.02	0.06	16.	27.	8.1	1.50
85 06 12	16.	81.	373.	0.02 L	0.04	16.	28.	9.1	1.00
85 06 16	18.	77.	361.	0.03	0.12	16.	27.	7.3	5.50
85 06 19	16.	81.	242.	0.02	0.02	20.	27.	8.7	1.50
85 06 23	16.	79.	364.	0.02 L	0.03	16.	27.	8.3	1.50
85 07 01	51.	80.	458.	0.19	2.51	16.	26.	9.4	100.00
85 07 04	16.	84.	385.	0.02 L	0.02	16.	28.	8.0	1.00
85 07 07	16.	82.	375.	0.02 L	0.03	15.	25.	9.4	1.00
85 07 10	16.	84.	385.	0.02 L	0.05	15.	26.	7.9	1.50
85 07 14	17.	92.	420.	0.02 L	0.02	15.	27.	6.8	0.90
85 07 17	16.	84.	384.	0.02	0.04	16.	27.	5.7	1.50
85 07 21	17.	89.	406.	0.02	0.03	16.	28.	6.3	1.00
85 07 24	16.	83.	379.	0.02	0.03	15.	28.	8.9	1.00
85 07 28	15.	83.	378.	0.02	0.02	16.	27.	9.0	1.50
85 07 31	16.	86.	394.	0.02 L	0.02	15.	29.	9.9	2.00
85 08 05	16.	86.	393.	0.02	0.02	16.	28.	9.9	1.00
85 08 07	16.	90.	410.	0.02	0.05	15.	29.	9.9	1.50
85 08 11	16.	87.	398.	0.02 L	0.02	16.	29.	8.6	1.50
85 08 14	15.	85.	387.	0.02	0.04	16.	25.	8.8	1.00
85 08 18	14.	82.	373.	0.02	0.10	16.	26.	8.9	1.00
85 08 21	14.	83.	379.	0.02 L	0.02 L	16.	27.	10.0	1.00
85 08 25	15.	85.	389.	0.02 L	0.02 L	15.	27.	9.9	0.70
85 09 02	13.	76.	342.	0.06	0.68	15.	24.	9.0	1.50
85 10 21	14.	89.	402.	0.02 L	0.02	17.	28.	8.2	1.00
86 01 08	14.	82.	372.	0.02 L	0.02 L	18.	28.	7.2	0.45

APPENDIX IV (b) Cont'd

STATION WQ0935, SOURCE - GULL LAKE
SAMPLING LOCATION - N E END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

DATE	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	SECCHI DISC METRES
85 06 06	0.5	1.60	0.01	0.01 L	0.015	12.	25.	2.9	3.20
85 06 09	0.5	1.80	0.01	0.01 L	0.030	12.	21.	3.5	2.80
85 06 12	0.4	1.80	0.01	0.53	0.035	13.	23.	1.8	3.50
85 06 16	0.5	1.80	0.01	0.01 L	0.040	12.	30.	0.0	3.60
85 06 19	0.6	1.80	0.01	0.09	0.020	13.	23.	3.5	3.60
85 06 23	0.6	1.90	0.01	0.04	0.025	13.	23.	2.6	3.00 G
85 07 01	1.1	1.80	0.01	0.01 L	0.090	14.	32.	3.5	3.00
85 07 04	0.7	1.80	0.01	0.01 L	0.020	14.	14.	2.6	2.50
85 07 07	1.0	1.80	0.01	0.01 L	0.030	13.	15.	3.5	2.20
85 07 10	0.9	1.70	0.01	0.02	0.020	15.	12.	6.3	2.80
85 07 14	1.2	1.70	0.00	0.01 L	0.015	14.	18.	5.3	2.20
85 07 17	1.5	1.80	0.00	0.03	0.020	15.	20.	5.3	2.60
85 07 21	1.6	1.70	0.01	0.01 L	0.015	14.	20.	4.4	2.00
85 07 24	1.4	1.80	0.00	0.01 L	0.020	14.	18.	6.1	2.00
85 07 28	2.2	2.00	0.01	0.01 L	0.020	16.	20.	3.5	1.90
85 07 31	2.4	1.90	0.00	0.01 L	0.020	14.	20.	3.5	2.00
85 08 05	2.6	1.80	0.02	0.01 L	0.025	14.	23.	3.5	2.40
85 08 07	2.6	2.00	0.07	0.01 L	0.020	14.	15.	3.5	2.20
85 08 11	2.9	2.10	0.01	0.01 L	0.020	14.	16.	3.5	2.20
85 08 14	3.4	1.70	0.01	0.01 L	0.015	14.	23.	4.8	2.20
85 08 18	3.2	1.80	0.03	0.01 L	0.025	13.	20.	3.5	2.60
85 08 21	3.1	1.70	0.01	0.01 L	0.015	14.	23.	3.1	2.30
85 08 25	2.9	1.60	0.01	0.03	0.015	14.	26.	2.2	3.20
85 09 02	2.9	1.80	0.01	0.05	0.015	14.	23.	3.5	3.00
85 10 21	2.9	1.80	0.02	0.01 L	0.015	14.	10.	1.9	---
86 01 08	3.0	1.80	0.12	0.01	0.011	16.	28.	---	---

APPENDIX IV (c):

STATION WQ0936, SOURCE - GULL LAKE
SAMPLING LOCATION - S CENTRAL LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

DATE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
85 06 06	677.0	520.	520.	5. L	9.00	374.	378.	38.	0.
85 06 09	689.0	470.	470.	5. L	9.00	374.	378.	38.	0.
85 06 12	685.0	470.	470.	5. L	8.95	370.	378.	36.	0.
85 06 16	---	---	---	---	---	---	---	---	---
85 06 19	680.0	510.	510.	5. L	8.95	378.	388.	36.	0.
85 06 23	701.0	470.	470.	5. L	9.00	380.	386.	38.	0.
85 07 01	701.0	520.	520.	5. L	8.95	372.	366.	43.	0.
85 07 04	680.0	500.	500.	5. L	9.00	376.	366.	46.	0.
85 07 07	696.0	490.	490.	5. L	9.05	378.	368.	46.	0.
85 07 10	691.0	470.	470.	5. L	9.00	384.	366.	50.	0.
85 07 14	690.0	470.	470.	5. L	9.00	378.	368.	46.	0.
85 07 17	689.0	250.	250.	5. L	9.05	384.	332.	67.	0.
85 07 21	701.0	490.	490.	5. L	9.20	384.	357.	58.	0.
85 07 24	691.0	500.	500.	5. L	9.10	384.	361.	53.	0.
85 07 28	708.0	500.	500.	5. L	9.15	384.	351.	58.	0.
85 07 31	713.0	520.	520.	5. L	9.20	372.	332.	60.	0.
85 08 05	685.0	490.	490.	5. L	9.15	380.	346.	58.	0.
85 08 07	668.0	510.	510.	5. L	9.15	386.	344.	62.	0.
85 08 11	667.0	490.	490.	5. L	9.20	390.	344.	65.	0.
85 08 14	663.0	480.	480.	5. L	9.15	382.	329.	67.	0.
85 08 18	658.0	470.	470.	5. L	9.05	374.	330.	60.	0.
85 08 21	659.0	510.	510.	5. L	9.15	376.	327.	65.	0.
85 08 25	647.0	470.	470.	5. L	9.20	372.	327.	62.	0.
85 09 02	653.0	470.	470.	5. L	9.15	374.	334.	60.	0.
85 10 21	652.0	470.	470.	5. L	9.15	374.	339.	58.	0.
86 01 08	732.0	510.	510.	5. L	8.95	412.	420.	41.	0.

APPENDIX IV (c) cont'd:

STATION WQ0936, SOURCE - GULL LAKE
SAMPLING LOCATION - S CENTRAL LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

DATE	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
85 06 06	15.	75.	345.	0.04	0.02 L	15.	26.	9.1	1.50
85 06 09	17.	82.	378.	0.02	0.03	15.	29.	8.2	1.50
85 06 12	16.	80.	368.	0.02 L	0.02 L	16.	28.	8.3	1.00
85 06 16	---	---	---	---	---	---	---	---	---
85 06 19	16.	81.	375.	0.02	0.02	20.	27.	8.7	1.00
85 06 23	16.	79.	364.	0.02 L	0.03	15.	26.	8.3	0.90
85 07 01	16.	77.	354.	0.02 L	0.02	15.	25.	10.0	1.00
85 07 04	17.	85.	389.	0.03	0.11	16.	28.	9.6	1.00
85 07 07	16.	81.	371.	0.02 L	0.02 L	15.	25.	8.3	1.00
85 07 10	16.	84.	383.	0.02 L	0.02 L	15.	26.	9.3	1.00
85 07 14	17.	92.	420.	0.02	0.03	15.	27.	7.1	0.95
85 07 17	16.	85.	387.	0.02	0.02	16.	27.	7.7	1.00
85 07 21	16.	84.	386.	0.05	0.03	15.	29.	8.0	1.00
85 07 24	16.	85.	389.	0.02	0.04	15.	28.	8.0	1.00
85 07 28	15.	83.	378.	0.02	0.02	16.	27.	9.7	1.00
85 07 31	16.	86.	395.	0.02 L	0.02	15.	29.	10.9	1.50
85 08 05	15.	86.	394.	0.02 L	0.02	16.	28.	9.7	1.50
85 08 07	16.	94.	427.	0.02	0.02	15.	30.	9.3	1.50
85 08 11	16.	87.	398.	0.02 L	0.02	16.	28.	9.0	1.50
85 08 14	14.	81.	368.	0.02	0.03	16.	26.	11.0	1.00
85 08 18	14.	83.	378.	0.02 L	0.03	16.	26.	9.4	1.00
85 08 21	14.	85.	386.	0.02 L	0.02 L	16.	28.	11.6	1.00
85 08 25	15.	83.	379.	0.02 L	0.02 L	15.	27.	11.9	1.00
85 09 02	13.	76.	344.	0.02 L	0.02	15.	24.	9.3	1.00
85 10 21	13.	84.	379.	0.02 L	0.02 L	17.	26.	8.8	0.75
86 01 08	14.	84.	379.	0.02	0.02 L	17.	28.	6.5	0.55

APPENDIX IV(c) cont'd

STATION WQ0936, SOURCE - GULL LAKE
SAMPLING LOCATION - S CENTRAL LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

DATE	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	SECCHI DISC METRES
85 06 06	0.6	1.70	0.01	0.01 L	0.015	12.	48.	8.7	3.10 G
85 06 09	0.5	1.80	0.00	0.01 L	0.030	12.	21.	4.9	2.80
85 06 12	0.4	1.70	0.01	0.05	0.020	13.	20.	3.5	2.80 G
85 06 16	---	---	---	---	---	---	---	---	2.80 G
85 06 19	0.4	1.80	0.01	0.01 L	0.020	13.	23.	5.3	2.80
85 06 23	0.5	1.70	0.01	0.01 L	0.020	13.	23.	2.6	2.60 G
85 07 01	0.7	1.80	0.01	0.01 L	0.020	14.	29.	4.4	2.70 G
85 07 04	0.7	1.80	0.01	0.09	0.020	14.	13.	10.5	2.40
85 07 07	0.7	1.70	0.01	0.01 L	0.020	13.	14.	2.9	2.20
85 07 10	0.8	1.80	0.02	0.05	0.015	15.	15.	3.9	2.30
85 07 14	1.4	1.70	0.02	0.01 L	0.015	15.	18.	4.4	2.20
85 07 17	1.5	1.80	0.03	0.06	0.025	15.	20.	7.0	2.60
85 07 21	1.8	1.70	0.01	0.01 L	0.020	13.	20.	4.4	2.20
85 07 24	1.9	1.80	0.01	0.01 L	0.020	14.	18.	5.3	2.00
85 07 28	2.4	1.80	0.00	0.01 L	0.020	10.	18.	4.4	2.00
85 07 31	2.5	1.80	0.00	0.01 L	0.020	14.	20.	3.5	2.10
85 08 05	2.6	1.80	0.01	0.01 L	0.020	14.	25.	3.5	2.00
85 08 07	2.7	1.80	0.01	0.01 L	0.015	14.	15.	3.5	2.20
85 08 11	2.6	2.00	0.01	0.01 L	0.020	14.	14.	3.9	2.20
85 08 14	3.4	1.70	0.01	0.01 L	0.015	14.	15.	6.6	2.20
85 08 18	3.4	1.80	0.01	0.01 L	0.025	13.	20.	3.1	2.50
85 08 21	3.1	1.70	0.02	0.01 L	0.020	14.	23.	3.5	2.50
85 08 25	2.9	1.60	0.02	0.01 L	0.025	14.	23.	3.1	2.20
85 09 02	2.9	1.70	0.02	0.01 L	0.015	13.	18.	6.1	2.80 G
85 10 21	3.0	1.80	0.02	0.01 L	0.010	14.	18.	22.7	---
86 01 08	3.0	1.80	0.09	0.01	0.016	16.	28.	---	---

APPENDIX IV(d)

STATION WQ0937, SOURCE - GULL LAKE
SAMPLING LOCATION - N N W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

DATE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
85 06 06	677.0	510.	510.	5. L	9.00	372.	376.	38.	0.
85 06 09	694.0	470.	470.	5. L	8.95	376.	381.	38.	0.
85 06 12	685.0	480.	480.	5. L	8.90	368.	381.	34.	0.
85 06 16	687.0	490.	490.	5. L	9.00	376.	381.	38.	0.
85 06 19	680.0	500.	500.	5. L	8.90	382.	393.	36.	0.
85 06 23	701.0	510.	510.	5. L	9.05	382.	383.	41.	0.
85 07 01	691.0	510.	510.	5. L	8.95	376.	371.	43.	0.
85 07 04	680.0	500.	500.	5. L	8.95	376.	366.	46.	0.
85 07 07	680.0	490.	490.	5. L	8.95	382.	378.	43.	0.
85 07 10	691.0	480.	480.	5. L	9.05	380.	366.	48.	0.
85 07 14	695.0	460.	460.	5. L	9.20	382.	359.	53.	0.
85 07 17	689.0	490.	490.	5. L	8.75	374.	344.	55.	0.
85 07 21	701.0	480.	480.	5. L	9.00	386.	364.	52.	0.
85 07 24	714.0	410.	410.	5. L	9.05	384.	346.	60.	0.
85 07 28	708.0	490.	490.	5. L	9.05	388.	356.	58.	0.
85 07 31	713.0	510.	510.	5. L	9.10	376.	332.	62.	0.
85 08 05	696.0	500.	500.	5. L	9.05	378.	349.	55.	0.
85 08 07	668.0	490.	490.	5. L	9.10	390.	349.	62.	0.
85 08 11	673.0	490.	490.	5. L	9.15	390.	339.	67.	0.
85 08 14	663.0	490.	490.	5. L	9.25	380.	332.	65.	0.
85 08 18	658.0	480.	480.	5. L	9.20	370.	320.	65.	0.
85 08 21	648.0	500.	500.	5. L	9.15	374.	325.	65.	0.
85 08 25	652.0	470.	470.	5. L	9.10	374.	334.	60.	0.
85 08 28	658.0	480.	480.	5. L	9.20	370.	320.	65.	0.
85 09 02	653.0	470.	470.	5. L	9.30	376.	327.	65.	0.
85 10 21	652.0	470.	470.	5. L	9.15	374.	329.	62.	0.
86 01 06	754.0	510.	510.	5. L	8.90	418.	422.	43.	0.

APPENDIX (d) Cont'd:

STATION WQ0937, SOURCE - GULL LAKE
SAMPLING LOCATION - N N W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

DATE	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
85 06 06	15.	75.	348.	0.02 L	0.02 L	15.	26.	9.2	0.85
85 06 09	17.	83.	382.	0.02	0.03	15.	30.	5.3	1.00
85 06 12	16.	79.	365.	0.02 L	0.02 L	16.	28.	9.2	1.00
85 06 16	16.	77.	357.	0.02 L	0.02 L	16.	27.	8.9	1.00
85 06 19	16.	80.	369.	0.02 L	0.02 L	21.	26.	8.7	0.85
85 06 23	15.	79.	362.	0.02 L	0.03	15.	27.	8.5	1.00
85 07 01	16.	77.	357.	0.02 L	0.02	15.	26.	8.2	1.00
85 07 04	17.	85.	391.	0.02 L	0.02	16.	28.	8.4	1.00
85 07 07	16.	80.	369.	0.02 L	0.03	15.	25.	8.7	1.00
85 07 10	16.	85.	391.	0.02 L	0.02 L	15.	27.	9.1	1.00
85 07 14	17.	94.	429.	0.03	0.03	15.	27.	6.5	0.90
85 07 17	16.	84.	739.	0.02	0.02	16.	27.	13.0	1.00
85 07 21	17.	84.	385.	0.02	0.03	16.	29.	7.6	1.00
85 07 24	16.	85.	389.	0.02 L	0.03	15.	28.	8.7	1.00
85 07 28	15.	82.	376.	0.02	0.03	16.	27.	9.6	1.00
85 07 31	16.	86.	394.	0.02 L	0.02 L	15.	29.	11.0	1.50
85 08 05	15.	87.	397.	0.02	0.04	16.	28.	9.1	1.50
85 08 07	16.	92.	418.	0.02	0.02	16.	30.	10.5	1.50
85 08 11	16.	87.	399.	0.02 L	0.02	16.	28.	9.4	1.00
85 08 14	15.	84.	382.	0.02	0.05	16.	26.	9.2	0.90
85 08 18	14.	84.	381.	0.02 L	0.03	16.	27.	10.0	1.00
85 08 21	14.	84.	381.	0.02 L	0.03	16.	27.	10.0	1.00
85 08 25	18.	92.	424.	0.07	0.25	15.	25.	10.0	1.00
85 08 28	14.	84.	381.	0.02 L	0.03	16.	27.	10.0	1.00
85 09 02	13.	75.	340.	0.02 L	0.02	15.	24.	9.4	1.50
85 10 21	14.	85.	384.	0.02 L	0.02	15.	27.	7.4	0.90
86 01 08	15.	90.	409.	0.02 L	0.03	17.	29.	7.8	0.95

APPENDIX IV (d) cont'd

STATION WQ0937, SOURCE - GULL LAKE
SAMPLING LOCATION - H N H END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

DATE	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	SECCHI DISC METRES
85 06 06	0.6	1.60	0.01	0.01 L	0.015	12.	44.	14.0	3.10
85 06 09	0.5	1.80	0.01	0.01 L	0.030	12.	17.	3.5	2.10 G
85 06 12	0.4	1.70	0.01	0.01 L	0.035	13.	23.	2.3	2.20 G
85 06 16	0.4	1.70	0.01	0.01 L	0.020	12.	20.	11.4	2.30 G
85 06 19	0.4	1.70	0.01	0.01 L	0.020	13.	23.	2.6	2.60 G
85 06 23	0.5	1.70	0.01	0.01 L	0.025	13.	23.	2.6	2.70 G
85 07 01	0.7	1.80	0.01	0.01 L	0.015	14.	27.	3.5	2.90 G
85 07 04	0.7	1.80	0.01	0.05	0.020	14.	14.	2.6	2.20
85 07 07	0.8	1.70	0.01	0.01 L	0.020	13.	14.	4.1	2.00
85 07 10	0.8	1.80	0.02	0.13	0.015	15.	16.	3.7	2.80
85 07 14	1.4	1.70	0.00	0.01 L	0.015	15.	18.	3.5	2.00
85 07 17	1.5	1.80	0.01	0.08	0.020	15.	20.	28.0	2.20
85 07 21	1.5	1.70	0.00	0.01	0.015	13.	20.	6.2	2.00
85 07 24	1.6	1.80	0.01	0.01 L	0.015	14.	18.	6.1	2.00
85 07 28	2.1	1.80	0.01	0.01 L	0.020	10.	18.	4.4	2.00
85 07 31	2.6	1.90	0.00	0.01 L	0.020	14.	15.	2.6	2.20
85 08 05	2.6	1.30	0.01	0.01 L	0.020	14.	28.	4.1	2.10
85 08 07	2.7	1.70	0.01	0.03	0.020	14.	15.	3.1	2.20
85 08 11	2.8	2.10	0.01	0.01 L	0.020	14.	15.	3.1	2.00
85 08 14	3.4	1.60	0.01	0.01 L	0.015	14.	20.	3.5	2.20 G
85 08 18	3.2	1.70	0.01	0.01 L	0.020	13.	10.	3.5	2.40
85 08 21	3.2	1.70	0.01	0.01 L	0.020	13.	10.	3.5	2.30
85 08 25	2.9	1.70	0.01	0.01 L	0.015	14.	22.	2.6	2.00 G
85 08 28	3.2	1.70	0.01	0.01 L	0.020	13.	10.	3.5	---
85 09 02	2.9	1.70	0.01	0.01	0.020	13.	18.	2.2	2.40 G
85 10 21	3.0	1.80	0.01	0.01 L	0.010	14.	18.	1.9	---
86 01 08	3.0	2.00	0.21	0.01	0.012	16.	33.	---	---

APPENDIX IV(e):

STATION MQ0938, SOURCE - GULL LAKE
SAMPLING LOCATION - S N ENT LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

DATE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
85 06 06	688.0	550.	490.	57.	8.85	378.	393.	34.	0.
85 06 09	666.0	470.	470.	5. L	8.95	372.	371.	41.	0.
85 06 12	685.0	480.	480.	5. L	8.95	366.	368.	38.	0.
85 06 16	684.0	480.	480.	5. L	8.85	378.	393.	34.	0.
85 06 19	680.0	500.	500.	5. L	9.00	376.	376.	41.	0.
85 06 23	707.0	490.	490.	5. L	8.90	382.	383.	41.	0.
85 07 01	697.0	510.	510.	5. L	8.95	374.	368.	43.	0.
85 07 04	688.0	490.	490.	5. L	9.00	374.	359.	48.	0.
85 07 07	680.0	500.	500.	5. L	9.10	376.	361.	48.	0.
85 07 10	691.0	470.	470.	5. L	9.00	380.	356.	53.	0.
85 07 14	738.0	480.	480.	5. L	9.10	378.	354.	53.	0.
85 07 17	689.0	490.	490.	5. L	9.00	380.	337.	62.	0.
85 07 21	695.0	490.	480.	9.	9.15	380.	337.	62.	0.
85 07 24	725.0	510.	510.	5. L	9.15	388.	351.	60.	0.
85 07 28	708.0	480.	480.	5. L	9.15	384.	351.	58.	0.
85 07 31	702.0	520.	520.	5. L	9.25	372.	337.	58.	0.
85 08 05	696.0	510.	510.	5. L	9.15	376.	342.	58.	0.
85 08 07	668.0	510.	510.	5. L	9.20	390.	339.	67.	0.
85 08 11	673.0	480.	480.	5. L	9.25	386.	334.	67.	0.
85 08 14	663.0	480.	480.	5. L	9.10	384.	327.	70.	0.
85 08 18	658.0	460.	460.	5. L	9.10	376.	332.	62.	0.
85 08 21	659.0	510.	510.	5. L	9.10	376.	327.	65.	0.
85 08 25	644.0	490.	470.	19.	9.20	374.	329.	62.	0.
85 09 02	653.0	470.	470.	5. L	9.20	380.	312.	74.	0.
85 10 21	652.0	480.	480.	5. L	9.15	370.	334.	58.	0.
86 01 08	771.0	540.	540.	5. L	8.95	440.	439.	48.	0.

APPENDIX IV(e) cont'd:

STATION WQ0938, SOURCE - GULL LAKE
SAMPLING LOCATION - S W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

DATE	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
85 06 06	16.	75.	348.	0.03	0.08	15.	26.	9.3	10.00
85 06 09	17.	83.	383.	0.02	0.02	15.	30.	5.9	1.00
85 06 12	16.	79.	366.	0.02 L	0.03	16.	28.	9.5	0.95
85 06 16	16.	76.	353.	0.02 L	0.02 L	16.	27.	8.2	1.00
85 06 19	16.	80.	368.	0.07	0.02 L	20.	26.	10.6	1.00
85 06 23	17.	83.	382.	0.02 L	0.03	16.	27.	8.1	1.00
85 07 01	17.	77.	357.	0.03	0.10	16.	26.	7.3	2.50
85 07 04	16.	85.	391.	0.02 L	0.11	16.	28.	10.0	0.80
85 07 07	15.	80.	369.	0.02 L	0.03	15.	25.	8.6	1.50
85 07 10	16.	85.	388.	0.02 L	0.02	15.	26.	9.4	1.50
85 07 14	17.	92.	419.	0.02 L	0.03	16.	27.	9.1	1.00
85 07 17	15.	81.	370.	0.02	0.04	16.	28.	8.2	1.00
85 07 21	17.	85.	391.	0.02	0.04	16.	28.	7.2	2.50
85 07 24	16.	84.	384.	0.02 L	0.03	15.	28.	10.0	1.00
85 07 28	16.	85.	387.	0.02	0.02	16.	28.	9.6	1.00
85 07 31	16.	86.	393.	0.02 L	0.02	16.	29.	11.1	1.50
85 08 05	15.	86.	392.	0.02	0.05	16.	28.	8.7	1.50
85 08 07	16.	92.	420.	0.02	0.04	16.	30.	11.0	1.50
85 08 11	16.	87.	398.	0.02 L	0.02	16.	28.	9.4	1.00
85 08 14	15.	85.	385.	0.02	0.04	16.	25.	8.9	1.00
85 08 18	14.	82.	374.	0.02 L	0.03	16.	26.	9.2	0.85
85 08 21	15.	86.	390.	0.02 L	0.02	16.	28.	10.4	1.00
85 08 25	16.	86.	393.	0.02 L	0.05	15.	26.	8.7	10.00
85 09 02	13.	75.	342.	0.02 L	0.02	15.	24.	9.2	1.00
85 10 21	14.	85.	386.	0.03	0.02	17.	27.	7.4	1.00
86 01 08	16.	95.	434.	0.29	0.13	17.	29.	8.9	0.65

APPRNDIX IV (e) cont'd:

STATION MQ0938, SOURCE - GULL LAKE
SAMPLING LOCATION - S M END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

DATE	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	SECCHI DISC METRES
85 06 06	0.7	1.80	0.01	0.01 L	0.040	12.	44.	1.8	1.90 G
85 06 09	0.4	1.80	0.01	0.01 L	0.030	12.	15.	2.3	3.00 G
85 06 12	0.4	1.80	0.01	0.01 L	0.025	13.	23.	5.3	2.90 G
85 06 16	0.4	1.70	0.01	0.01 L	0.015	12.	20.	7.0	2.00 G
85 06 19	0.4	1.80	0.01	0.01 L	0.020	13.	23.	3.5	2.30 G
85 06 23	0.5	1.80	0.01	0.01 L	0.020	13.	23.	7.0	2.00 G
85 07 01	0.8	2.00	0.02	0.01 L	0.040	14.	25.	1.8	2.60
85 07 04	0.7	1.80	0.01	0.01 L	0.020	14.	13.	52.5	2.20
85 07 07	0.9	1.90	0.01	0.01 L	0.030	13.	14.	4.1	2.00 G
85 07 10	1.0	1.90	0.07	0.02	0.030	15.	16.	0.0	2.20 G
85 07 14	1.6	1.80	0.02	0.01 L	0.025	15.	18.	7.0	2.00 G
85 07 17	1.6	1.80	0.03	0.01 L	0.025	15.	20.	6.1	2.00
85 07 21	1.3	2.10	0.00	0.01 L	0.035	14.	20.	8.7	1.80
85 07 24	1.5	2.00	0.01	0.01 L	0.030	14.	20.	8.7	2.00
85 07 28	2.3	1.80	0.01	0.01 L	0.025	10.	18.	5.3	2.00
85 07 31	2.6	2.00	0.01	0.01 L	0.030	14.	15.	4.1	1.90
85 08 05	2.7	1.90	0.02	0.01 L	0.025	14.	25.	5.3	2.00
85 08 07	2.9	1.80	0.01	0.01 L	0.025	14.	15.	6.1	2.00
85 08 11	2.8	2.20	0.01	0.01 L	0.025	14.	15.	3.1	2.00
85 08 14	3.4	1.60	0.01	0.01 L	0.015	14.	20.	3.9	2.50 G
85 08 18	3.0	1.70	0.01	0.01 L	0.025	13.	20.	3.9	2.50 G
85 08 21	2.9	1.70	0.01	0.01 L	0.025	14.	15.	4.8	2.20
85 08 25	2.8	1.60	0.01	0.01 L	0.020	14.	22.	2.6	2.00 G
85 09 02	2.9	1.70	0.01	0.01 L	0.020	13.	18.	2.2	2.20 G
85 10 21	3.0	2.00	0.02	0.01 L	0.010	14.	18.	2.3	---
86 01 08	2.8	1.90	0.05	0.01	0.015	17.	33.	---	---

APPENDIX IV (f)

STATION WQ0939, SOURCE - GULL LAKE
SAMPLING LOCATION - N W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

DATE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
85 06 06	677.0	510.	510.	5. L	9.00	376.	376.	41.	0.
85 06 09	684.0	470.	470.	5. L	8.95	380.	386.	38.	0.
85 06 12	685.0	470.	470.	5. L	8.90	366.	373.	36.	0.
85 06 16	684.0	470.	470.	5. L	8.95	380.	386.	38.	0.
85 06 19	688.0	500.	500.	5. L	8.90	378.	378.	41.	0.
85 06 23	707.0	490.	490.	5. L	9.10	380.	371.	46.	0.
85 07 01	701.0	500.	500.	5. L	8.90	378.	368.	46.	0.
85 07 04	688.0	480.	480.	5. L	8.95	376.	366.	46.	0.
85 07 07	680.0	490.	490.	5. L	8.95	380.	376.	43.	0.
85 07 10	691.0	490.	490.	5. L	9.05	384.	361.	53.	0.
85 07 14	691.0	480.	470.	7.	9.00	380.	361.	50.	0.
85 07 17	689.0	490.	490.	5. L	8.85	382.	349.	58.	0.
85 07 21	684.0	500.	490.	11.	9.05	382.	349.	58.	0.
85 07 24	703.0	520.	520.	5. L	9.05	388.	351.	60.	0.
85 07 28	711.0	500.	500.	5. L	9.05	390.	354.	60.	0.
85 07 31	713.0	700.	700.	5. L	9.10	376.	332.	62.	0.
85 08 05	696.0	500.	500.	5. L	9.05	378.	344.	58.	0.
85 08 07	668.0	510.	510.	5. L	9.10	392.	356.	60.	0.
85 08 11	669.0	490.	490.	5. L	9.15	390.	339.	67.	0.
85 08 14	663.0	480.	480.	5. L	9.20	378.	329.	65.	0.
85 08 18	658.0	470.	470.	5. L	9.15	376.	327.	65.	0.
85 08 21	659.0	520.	510.	6.	9.15	372.	337.	58.	0.
85 08 25	655.0	480.	480.	5. L	9.10	374.	334.	60.	0.
85 09 02	653.0	470.	470.	5. L	9.25	374.	329.	62.	0.
85 10 21	652.0	460.	460.	5. L	9.15	376.	342.	58.	0.
86 01 08	776.0	530.	530.	5. L	9.00	430.	422.	50.	0.

APPENDIX IV (f) cont'd:

STATION WQ0939, SOURCE - GULL LAKE
SAMPLING LOCATION - N W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

DATE	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
85 06 06	15.	73.	338.	0.02 L	0.02 L	15.	25.	9.2	0.80
85 06 09	17.	82.	381.	0.02	0.04	16.	30.	7.7	1.00
85 06 12	16.	79.	366.	0.02 L	0.03	16.	28.	9.8	1.00
85 06 16	16.	78.	360.	0.02 L	0.02	16.	27.	8.2	1.00
85 06 19	16.	80.	370.	0.02	0.02	20.	26.	9.6	1.00
85 06 23	17.	83.	382.	0.02 L	0.02	16.	27.	8.1	1.00
85 07 01	15.	77.	355.	0.02 L	0.02 L	15.	25.	6.8	1.00
85 07 04	16.	83.	379.	0.02 L	0.02	16.	28.	9.0	1.00
85 07 07	15.	81.	371.	0.02 L	0.02	15.	25.	8.6	1.50
85 07 10	16.	84.	387.	0.02 L	0.02 L	15.	27.	9.9	1.00
85 07 14	17.	93.	427.	0.02 L	0.02	15.	27.	9.1	0.90
85 07 17	15.	79.	361.	0.02	0.02	16.	28.	8.4	1.50
85 07 21	16.	84.	413.	0.02	0.02	16.	29.	6.9	3.00
85 07 24	16.	85.	388.	0.02	0.03	15.	29.	8.5	1.00
85 07 28	15.	83.	380.	0.02	0.02	16.	27.	9.8	1.50
85 07 31	16.	86.	391.	0.02 L	0.02 L	16.	29.	10.7	1.50
85 08 05	16.	87.	396.	0.02	0.04	16.	28.	9.1	2.00
85 08 07	16.	94.	427.	0.02	0.04	16.	30.	9.9	1.00
85 08 11	16.	87.	396.	0.02 L	0.02	16.	29.	8.8	1.00
85 08 14	15.	84.	382.	0.02	0.04	17.	25.	8.9	1.00
85 08 18	14.	84.	381.	0.02 L	0.03	16.	27.	9.5	0.85
85 08 21	14.	85.	383.	0.02 L	0.02 L	15.	28.	10.8	2.00
85 08 25	15.	84.	380.	0.02 L	0.02 L	15.	26.	11.3	2.00
85 09 02	13.	80.	360.	0.02 L	0.02	15.	25.	8.8	1.00
85 10 21	14.	85.	384.	0.02 L	0.02	17.	27.	8.1	1.00
86 01 08	16.	95.	433.	0.39	0.03	17.	29.	9.6	0.80

APPENDIX IV(f) cont'd:

STATION WQ0939, SOURCE - GULL LAKE
SAMPLING LOCATION - N W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

DATE	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	SECCHI DISC METRES
85 06 06	0.7	1.60	0.01	0.01 L	0.015	12.	44.	10.5	2.90 G
85 06 09	0.4	1.80	0.01	0.01 L	0.030	12.	15.	4.1	2.80 G
85 06 12	0.4	1.80	0.01	0.02	0.020	13.	3.	14.0	3.00 G
85 06 16	0.4	1.70	0.01	0.01 L	0.020	12.	28.	3.5	2.80 G
85 06 19	0.5	1.90	0.01	0.04	0.035	13.	20.	1.8	2.00 G
85 06 23	0.5	1.70	0.02	0.02	0.020	13.	20.	3.5	2.00 G
85 07 01	0.6	1.70	0.01	0.01 L	0.020	14.	27.	4.4	2.60 G
85 07 04	0.5	1.90	0.02	0.06	0.020	13.	14.	4.2	2.20
85 07 07	0.8	1.80	0.01	0.01 L	0.030	13.	14.	3.5	1.90
85 07 10	1.0	1.80	0.03	0.03	0.020	14.	15.	3.5	2.20
85 07 14	1.2	1.80	0.02	0.01 L	0.020	15.	18.	5.3	2.10
85 07 17	1.6	1.90	0.01	0.02	0.025	15.	20.	29.7	2.20
85 07 21	1.8	1.80	0.01	0.01 L	0.020	14.	20.	7.0	2.00
85 07 24	1.5	1.90	0.01	0.01 L	0.020	14.	20.	4.4	2.00
85 07 28	2.2	1.80	0.01	0.01 L	0.025	10.	18.	8.7	1.90
85 07 31	2.5	2.00	0.00	0.01 L	0.020	14.	15.	3.5	2.00
85 08 05	2.8	0.60	0.02	0.01 L	0.020	14.	25.	5.3	2.30
85 08 07	2.7	1.80	0.01	0.01 L	0.020	14.	15.	3.1	2.20
85 08 11	2.8	2.00	0.01	0.01 L	0.025	14.	15.	7.0	2.20
85 08 14	3.4	1.60	0.06	0.01 L	0.015	14.	18.	3.9	2.20
85 08 18	3.0	1.70	0.01	0.01 L	0.015	13.	16.	4.4	2.20
85 08 21	2.9	1.80	0.05	0.01 L	0.030	14.	15.	3.1	2.30
85 08 25	2.9	1.60	0.01	0.01 L	0.015	14.	22.	2.6	2.00 G
85 09 02	2.8	1.70	0.01	0.06	0.015	13.	18.	2.2	2.00 G
85 10 21	2.9	1.80	0.02	0.01	0.015	14.	15.	2.3	---
86 01 08	2.8	1.90	0.05	0.01	0.013	17.	28.	---	---

APPENDIX V (a)

STATION WQ0934, SOURCE - GULL LAKE
SAMPLING LOCATION - E END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

STATISTICS	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
NO. OF DATA	25	25	25	25	25	25	25	25	25
WITH 'L'	0	0	0	25	0	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	0
MEAN	690.3	508.	508.	5. *	9.05	381.	362.	51.	0.
STANDARD DEV.	23.45	84.2	84.2	0.0*		11.1	24.3	10.0	0.0
MEDIAN	694.0	490.	490.	5. L	9.05	378.	366.	48.	0.
HIGH	747.0	900.	900.	5. L	9.25	428.	425.	72.	0.
LOW	647.0	460.	460.	5. L	8.90	370.	312.	36.	0.
10 PERCENTILE	658.2	470.	470.	5. L	8.92	372.	329.	38.	0.
90 PERCENTILE	719.4	528.	528.	5. L	9.18	386.	383.	61.	0.

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V (a) cont'd:

STATION WQ0934, SOURCE - GULL LAKE
SAMPLING LOCATION - E END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

STATISTICS	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
NO. OF DATA	25	25	25	25	25	25	25	25	25
WITH 'L'	0	0	0	13	2	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	0
MEAN	15.	84.	378.	0.02 *	0.03 *	16.	27.	8.7	1.17
STANDARD DEV.	1.6	4.6	41.4	0.003 *	0.013 *	1.1	1.4	1.35	0.285
MEDIAN	16.	84.	384.	0.02 L	0.03	16.	27.	8.6	1.00
HIGH	17.	92.	418.	0.03	0.06	20.	31.	12.4	1.50
LOW	8.	73.	201.	0.02 L	0.02 L	15.	25.	5.6	0.70
10 PERCENTILE	15.	80.	358.	0.02 L	0.02	15.	26.	7.1	0.90
90 PERCENTILE	17.	90.	409.	0.02	0.05	16.	29.	9.8	1.50

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V(a) cont'd:

STATION HQ0934, SOURCE - GULL LAKE
SAMPLING LOCATION - E END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

STATISTICS	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	SECCHI DISC METRES
NO. OF DATA	25	25	25	25	25	25	25	24	24
WITH 'L'	0	0	0	18	0	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	7
MEAN	1.8	1.80	0.02	0.03 *	0.022	14.	22.	4.2	2.47 *
STANDARD DEV.	1.02	0.149	0.013	0.035 *	0.0102	0.9	6.6	2.83	0.518 *
MEDIAN	1.6	1.80	0.01	0.01 L	0.020	14.	20.	3.5	2.40 G
HIGH	3.4	2.20	0.06	0.16	0.065	16.	45.	14.0	3.50 G
LOW	0.5	1.50	0.00	0.01 L	0.015	12.	14.	1.3	1.90
90 PERCENTILE	3.0	2.00	0.04	0.06	0.028	15.	27.	7.0	3.17 G
10 PERCENTILE	0.6	1.64	0.01	0.01 L	0.015	13.	16.	1.8	1.90

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V (b):

STATION WQ0935, SOURCE - GULL LAKE
SAMPLING LOCATION - N E END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

STATISTICS	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
NO. OF DATA	26	26	26	26	26	26	26	26	26
WITH 'L'	0	0	0	22	0	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	0
MEAN	685.6	505.	489.	20. *	9.04	381.	361.	51.	0.
STANDARD DEV.	20.89	78.8	17.7	73.4*		9.8	25.0	10.0	0.0
MEDIAN	686.0	495.	485.	5. L	9.10	380.	361.	52.	0.
HIGH	738.0	880.	520.	380.	9.25	414.	422.	67.	0.
LOW	652.0	450.	450.	5. L	8.85	366.	325.	36.	0.
10 PERCENTILE	656.5	470.	470.	5. L	8.90	372.	333.	38.	0.
90 PERCENTILE	709.0	520.	510.	9.	9.18	389.	387.	62.	0.

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V (b) cont'd

STATION WQ0935, SOURCE - GULL LAKE
SAMPLING LOCATION - N E END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

STATISTICS	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
NO. OF DATA	26	26	26	26	26	26	26	26	26
WITH 'L'	0	0	0	12	3	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	0
MEAN	17.	83.	380.	0.03 *	0.16 *	16.	27.	8.5	5.21
STANDARD DEV.	7.1	4.3	36.5	0.034 *	0.497 *	1.1	1.2	1.14	19.355
MEDIAN	16.	84.	385.	0.02	0.03	16.	27.	8.8	1.25
HIGH	51.	92.	458.	0.19	2.51	20.	29.	10.0	100.00
LOW	13.	74.	242.	0.02 L	0.02 L	15.	24.	5.7	0.45
10 PERCENTILE	14.	78.	353.	0.02 L	0.02 L	15.	26.	7.0	0.95
90 PERCENTILE	17.	89.	408.	0.04	0.11	16.	28.	9.9	2.25

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V(b) cont'd:

STATION WQ0935, SOURCE - GULL LAKE
SAMPLING LOCATION - N E END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

STATISTICS	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	SECCHI DISC METRES
NO. OF DATA	26	26	26	26	26	26	26	25	24
WITH 'L'	0	0	0	18	0	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	1
MEAN	1.8	1.80	0.02	0.04 *	0.023	14.	21.	3.5	2.62 *
STANDARD DEV.	1.06	0.113	0.025	0.102 *	0.0152	1.0	4.8	1.37	0.535 *
MEDIAN	1.6	1.80	0.01	0.01 L	0.020	14.	21.	3.5	2.55
HIGH	3.4	2.10	0.12	0.53	0.090	16.	32.	6.3	3.60
LOW	0.4	1.60	0.00	0.01 L	0.011	12.	12.	0.0	1.90
90 PERCENTILE	3.1	1.95	0.02	0.05	0.033	15.	27.	5.3	3.41 G
10 PERCENTILE	0.5	1.70	0.00	0.01 L	0.015	13.	15.	2.0	2.00

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V (c):

STATION M20936, SOURCE - GULL LAKE
SAMPLING LOCATION - S CENTRAL LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

STATISTICS	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
NO. OF DATA	25	25	25	25	25	25	25	25	25
WITH 'L'	0	0	0	25	0	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	0
MEAN	683.0	481.	481.	5. *	9.07	380.	357.	52.	0.
STANDARD DEV.	21.03	51.6	51.6	0.0*		8.6	23.5	10.6	0.0
MEDIAN	685.0	490.	490.	5. L	9.05	378.	357.	58.	0.
HIGH	732.0	520.	520.	5. L	9.20	412.	420.	67.	0.
LOW	647.0	250.	250.	5. L	8.95	370.	327.	36.	0.
10 PERCENTILE	655.0	470.	470.	5. L	8.95	372.	330.	38.	0.
90 PERCENTILE	705.2	516.	516.	5. L	9.20	385.	383.	65.	0.

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V (c) cont'd:

STATION WQ0936, SOURCE - GULL LAKE
SAMPLING LOCATION - S CENTRAL LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

STATISTICS	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
NO. OF DATA	25	25	25	25	25	25	25	25	25
WITH 'L'	0	0	0	13	8	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	0
MEAN	15.	83.	381.	0.02 *	0.03 *	16.	27.	9.1	1.09
STANDARD DEV.	1.0	4.4	19.0	0.007 *	0.018 *	1.1	1.5	1.31	0.258
MEDIAN	16.	84.	379.	0.02 L	0.02	15.	27.	9.1	1.00
HIGH	17.	94.	427.	0.05	0.11	20.	30.	11.9	1.50
LOW	13.	75.	344.	0.02 L	0.02 L	15.	24.	6.5	0.55
10 PERCENTILE	14.	77.	358.	0.02 L	0.02 L	15.	25.	7.8	0.92
90 PERCENTILE	16.	87.	397.	0.03	0.03	16.	29.	11.0	1.50

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V(c) cont'd:

STATION WQ0936, SOURCE - GULL LAKE
SAMPLING LOCATION - S CENTRAL LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

STATISTICS	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	SECCHI DISC METRES
NO. OF DATA	25	25	25	25	25	25	25	24	24
WITH 'L'	0	0	0	20	0	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	6
MEAN	1.9	1.76	0.01	0.02 *	0.019	14.	21.	5.5	2.42 *
STANDARD DEV.	1.09	0.076	0.018	0.021 *	0.0042	1.2	7.0	4.13	0.318 *
MEDIAN	1.9	1.80	0.01	0.01 L	0.020	14.	20.	4.4	2.35
HIGH	3.4	2.00	0.09	0.09	0.030	16.	48.	22.7	3.10 G
LOW	0.4	1.60	0.00	0.01 L	0.010	10.	13.	2.6	2.00
90 PERCENTILE	3.1	1.80	0.02	0.05	0.025	15.	27.	8.2	2.80 G
10 PERCENTILE	0.5	1.70	0.00	0.01 L	0.015	12.	15.	3.1	2.03

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V(d)

STATION WQ0937, SOURCE - GULL LAKE
SAMPLING LOCATION - N N W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

STATISTICS	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
NO. OF DATA	27	27	27	27	27	27	27	27	27
WITH 'L'	0	0	0	27	0	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	0
MEAN	683.7	486.	486.	5. *	9.03	380.	356.	53.	0.
STANDARD DEV.	23.91	21.0	21.0	0.0*		9.7	25.6	10.9	0.0
MEDIAN	685.0	490.	490.	5. L	9.05	376.	356.	55.	0.
HIGH	754.0	510.	510.	5. L	9.30	418.	422.	67.	0.
LOW	648.0	410.	410.	5. L	8.75	368.	320.	34.	0.
90 PERCENTILE	710.0	510.	510.	5. L	9.20	389.	382.	65.	0.
10 PERCENTILE	652.6	470.	470.	5. L	8.90	371.	326.	38.	0.

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V (d) cont'd:

STATION WQ0937, SOURCE - GULL LAKE
SAMPLING LOCATION - N N W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

STATISTICS	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
NO. OF DATA	27	27	27	27	27	27	27	27	27
WITH 'L'	0	0	0	18	6	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	0
MEAN	16.	84.	396.	0.02 *	0.03 *	16.	27.	9.0	1.05
STANDARD DEV.	1.1	4.9	71.8	0.010 *	0.044 *	1.1	1.4	1.45	0.197
MEDIAN	16.	84.	382.	0.02 L	0.03	16.	27.	9.1	1.00
HIGH	18.	94.	73a.	0.07	0.25	21.	30.	13.0	1.50
LOW	13.	75.	340.	0.02 L	0.02 L	15.	24.	5.3	0.85
90 PERCENTILE	17.	91.	420.	0.02	0.03	16.	29.	10.2	1.50
10 PERCENTILE	14.	77.	357.	0.02 L	0.02 L	15.	25.	7.5	0.90

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V(d):

STATION WQ0937, SOURCE - GULL LAKE
SAMPLING LOCATION - N N W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

STATISTICS	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	SECCHI DISC METRES
NO. OF DATA	27	27	27	27	27	27	27	26	24
WITH 'L'	0	0	0	20	0	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	9
MEAN	1.8	1.74	0.02	0.02 *	0.019	13.	20.	5.1	2.29 *
STANDARD DEV.	1.12	0.139	0.039	0.027 *	0.0051	1.2	7.3	5.42	0.315 *
MEDIAN	1.6	1.70	0.01	0.01 L	0.020	14.	18.	3.5	2.20 G
HIGH	3.4	2.10	0.21	0.13	0.035	16.	44.	28.0	3.10
LOW	0.4	1.30	0.00	0.01 L	0.010	10.	10.	1.9	2.00
90 PERCENTILE	3.2	1.84	0.01	0.04	0.022	15.	27.	8.8	2.77 G
10 PERCENTILE	0.5	1.66	0.00	0.01 L	0.015	12.	12.	2.5	2.00

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V(e)

STATION WQ0938, SOURCE - GULL LAKE
SAMPLING LOCATION - S W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

STATISTICS	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
NO. OF DATA	26	26	26	26	26	26	26	26	26
WITH 'L'	0	0	0	23	0	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	0
MEAN	686.9	494.	490.	8. *	9.05	380.	354.	54.	0.
STANDARD DEV.	28.27	21.6	18.9	10.4*		13.4	27.4	11.5	0.0
MEDIAN	686.5	490.	485.	5. L	9.10	378.	351.	58.	0.
HIGH	771.0	550.	540.	57.	9.25	440.	439.	74.	0.
LOW	644.0	460.	460.	5. L	8.85	366.	312.	34.	0.
90 PERCENTILE	716.5	515.	510.	7. L	9.20	387.	388.	67.	0.
10 PERCENTILE	655.5	470.	470.	5. L	8.93	372.	328.	40.	0.

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V(e) cont'd:

STATION WR0938, SOURCE - GULL LAKE
SAMPLING LOCATION - S W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

STATISTICS	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
NO. OF DATA	26	26	26	26	26	26	26	26	26
WITH 'L'	0	0	0	14	2	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	0
MEAN	16.	84.	383.	0.03 *	0.04 *	16.	27.	9.0	1.87
STANDARD DEV.	1.0	5.0	21.4	0.053 *	0.024 *	1.0	1.5	1.25	2.433
MEDIAN	16.	85.	386.	0.02 L	0.03	16.	27.	9.2	1.00
HIGH	17.	95.	434.	0.29	0.11	20.	30.	11.1	10.00
LOW	13.	75.	342.	0.02 L	0.02 L	15.	24.	5.9	0.65
90 PERCENTILE	17.	89.	409.	0.03	0.07	16.	29.	10.7	2.50
10 PERCENTILE	14.	76.	355.	0.02 L	0.02	15.	26.	7.4	0.90

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V(e) cont'd:

STATION WQ0938, SOURCE - GULL LAKE
SAMPLING LOCATION - S W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

STATISTICS	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	SECCHI DISC METRES
NO. OF DATA	26	26	26	26	26	26	26	25	24
WITH 'L'	0	0	0	24	0	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	13
MEAN	1.8	1.64	0.02	0.01 *	0.025	14.	20.	6.1	2.17 *
STANDARD DEV.	1.07	0.145	0.014	0.002 *	0.0073	1.3	6.5	9.87	0.312 *
MEDIAN	1.6	1.60	0.01	0.01 L	0.025	14.	20.	4.1	2.00 G
HIGH	3.4	2.20	0.07	0.02	0.040	17.	44.	52.5	3.00 G
LOW	0.4	1.60	0.00	0.01 L	0.010	10.	13.	0.0	1.80
90 PERCENTILE	3.0	2.00	0.03	0.01 L	0.033	15.	25.	8.0	2.57 G
10 PERCENTILE	0.4	1.70	0.01	0.01 L	0.015	12.	15.	1.9	1.93 G

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V (f):

STATION WQ0939, SOURCE - GULL LAKE
SAMPLING LOCATION - N W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

STATISTICS	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
NO. OF DATA	26	26	26	26	26	26	26	26	26
WITH 'L'	0	0	0	23	0	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	0
MEAN	685.6	499.	498.	5. *	9.03	381.	358.	53.	0.
STANDARD DEV.	25.74	44.8	44.8	1.2*		11.5	22.5	9.5	0.0
MEDIAN	684.5	490.	490.	5. L	9.05	379.	355.	58.	0.
HIGH	776.0	700.	700.	11.	9.25	430.	422.	67.	0.
LOW	652.0	460.	460.	5. L	8.85	366.	327.	36.	0.
10 PERCENTILE	656.5	470.	470.	5. L	8.90	374.	331.	40.	0.
90 PERCENTILE	709.0	520.	515.	6. L	9.15	390.	382.	64.	0.

* - STANDARD DEVIATIONS AND MEANS FLAGGED BY AN ASTERISK HAVE BEEN CALCULATED WITH AT LEAST ONE "LESS THAN" (L) AND/OR "GREATER THAN" (G) VALUE. THESE VALUES ARE ENTERED INTO THE CALCULATION AS THE NUMERICAL EQUIVALENT TO THE REPORTED VALUE. PARAMETER VALUES ARE QUALIFIED BY "L" OR "G" WHEN LABORATORY PROCEDURES WERE NOT CAPABLE OF GREATER ACCURACY. SUCH CALCULATED STATISTICS SHOULD BE INTERPRETED ACCORDINGLY.

NOTE:- 1. IF NUMBER OF DATA IS LESS THAN 4, THEN STATISTICAL CALCULATIONS ARE NOT PERFORMED.
2. THE MEAN FOR PH IS COMPUTED BY CALCULATING THE MEAN OF THE ORIGINAL CONCENTRATION OF HYDROGEN IONS, AND THEN CONVERTING THAT VALUE BACK TO PH UNITS.
3. THE MEAN FOR COLIFORM IS COMPUTED AS THE GEOMETRIC MEAN.
4. THE STANDARD DEVIATION IS COMPUTED ONLY FOR PARAMETERS THAT HAVE AN ARITHMETIC MEAN.

APPENDIX V (f) cont'd:

STATION WQ0939, SOURCE - GULL LAKE
SAMPLING LOCATION - N W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 30

STATISTICS	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
NO. OF DATA	26	26	26	26	26	26	26	26	26
WITH 'L'	0	0	0	16	6	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	0
MEAN	15.	84.	384.	0.03 *	0.02 *	16.	27.	9.0	1.24
STANDARD DEV.	1.0	5.0	22.5	0.073 *	0.008 *	1.1	1.5	1.08	0.512
MEDIAN	16.	84.	382.	0.02 L	0.02	16.	27.	9.1	1.00
HIGH	17.	95.	433.	0.39	0.04	20.	30.	11.3	3.00
LOW	13.	73.	338.	0.02 L	0.02 L	15.	25.	6.8	0.80
10 PERCENTILE	14.	78.	360.	0.02 L	0.02 L	15.	25.	7.9	0.88
90 PERCENTILE	17.	90.	420.	0.02	0.04	17.	29.	10.3	2.00

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APPENDIX V(f) cont'd:

STATION MQ0939, SOURCE - GULL LAKE
SAMPLING LOCATION - N W END LATITUDE 50:24 LONGITUDE 096:31

FROM 85 06 01
TO 86 01 31

STATISTICS	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	SECCHI DISC METRES
NO. OF DATA	26	26	26	26	26	26	26	25	24
WITH 'L'	0	0	0	17	0	0	0	0	0
WITH 'G'	0	0	0	0	0	0	0	0	9
MEAN	1.8	1.75	0.02	0.02 *	0.021	14.	19.	5.8	2.25 *
STANDARD DEV.	1.07	0.258	0.014	0.015 *	0.0056	1.3	7.3	5.71	0.326 *
MEDIAN	1.7	1.80	0.01	0.01 L	0.020	14.	18.	4.1	2.20 G
HIGH	3.4	2.00	0.06	0.06	0.035	17.	44.	29.7	3.00 G
LOW	0.4	0.60	0.00	0.01 L	0.013	10.	3.	1.8	1.90
90 PERCENTILE	2.9	1.90	0.04	0.04	0.030	15.	28.	9.8	2.80 G
10 PERCENTILE	0.5	1.60	0.01	0.01 L	0.015	12.	14.	2.4	2.00

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